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RELATIVE GROWTH OF THE LIMB SEGMENTS AND TAIL IN MACAQUES

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INTRODUCTION

IN an earlier investigation on the anthropoid apes (Lumer, 1939) it was shown that the relative growth of the limb bones conforms to the law of allometry

$$y = bx^a$$

in which x and y represent the sizes of two parts of the body, and b and a are constants. The values of these constants provide a concise quantitative characterization of the growth relations of the parts concerned, and are thus particularly useful in analyzing and interpreting differences in body proportions, both in different ontogenetic stages of a particular type of organism and in corresponding stages of related types.

The purpose of the present study is to make a similar analysis for the macaques, and to compare the relative growth of the limb segments in these forms, as representatives of the catarrhine monkeys, with that in the higher primates. The measurements and related data on which the study is based were supplied by the second of the two authors, while the first is responsible for the analysis and conclusions.

TABLE 1. AVERAGE LENGTHS IN MILLIMETERS OF TRUNK, LIMB SEGMENTS, AND TAIL IN FETAL, INFANTILE, JUVENILE, AND ADULT STAGES OF SIX SPECIES OF MACAQUES

The infantile stage is terminated by the completion of the deciduous dentition and the juvenile by the completion of the permanent dentition. The numbers in parentheses under "Tail length" represent in each case the number of specimens for which the particular average was obtained.

SPECIES	AGE	NUMBER	TRUNK HEIGHT	RANGE OF VARIATION	KNEE HEIGHT	THIGH LENGTH	LEG LENGTH	FOOT LENGTH	UPPER ARM LENGTH	FORE-ARM LENGTH	HAND LENGTH	TAIL LENGTH
M. mulatta	Fetus	32	77.2	8.5-124	32.4	31.2	27.7	47.4	30.0	27.0	24.9	71.0
"	Infant	10	175.5	130-230	97.0	92.2	85.6	96.8	81.6	77.2	62.3	152.0
"	Juven.	7	262.6	242-300	144.4	138.7	128.3	135.0	117.0	112.1	82.1	201.0(6)
"	Adult ♀	17	337.8	308-367	168.4	166.9	151.2	147.5	144.4	136.9	94.8	227.9
"	Adult ♂	7	363.9	327-396	181.9	178.1	163.0	161.3	150.7	148.7	107.1	264.9
"	Ad. ♂ & ♀	24	345.4	308-396	172.3	170.2	154.6	151.5	146.2	140.3	98.4	238.7
M. philippinensis	Infant	2	145.0	110-180	83.5	78.5	74.0	82.0	75.5	67.5	51.5	314.0
"	Juven.	16	236.3	202-263	126.1	122.9	112.6	115.9	110.8	104.8	75.3	455.0(13)
"	Adult ♀	3	263.3	256-276	135.3	132.7	119.7	118.0	119.3	114.0	80.0	505.5(2)
"	Adult ♂	4	260.0	234-270	142.3	141.0	129.3	128.0	124.5	120.5	82.8	527.0(3)
"	Ad. ♂ & ♀	7	261.4	234-276	139.3	137.4	125.1	123.7	122.3	117.7	81.6	518.4(5)

TABLE 1 (*Continued*)

M. sinicus	Fetus	1	79	.....	50	46	42	53	44	42	36	195
"	Infant	1	201	.....	110	107	99	100	93	92	65	362
"	Juven.	1	275	.....	145	148	131	122	126	123	87	481
"	Adult ♀	1	293	.....	149	146	135	127	130	122	85	530
"	Adult ♂	3	324.7	318-337	174.0	176.3	157.3	147.0	153.0	148.3	96.7	573.3
"	Ad. ♂ & ♀	4	316.8	293-337	167.8	168.8	151.8	142.0	147.8	141.8	93.8	562.5
M. speciosus	Adult ♀	1	314	.....	146	164	125	149	151	145	104	40
M. irus	Fetus	5	63.6	32-84	36.3	34.7	31.3	41.0	34.5	31.2	27.8	142.4
"	Adult ♀	5	270.6	253-278	128.6	131.2	116.8	112.2	117.6	109.8	75.6	506.0
"	Adult ♂	10	299.7	279-320	145.2	147.2	130.5	127.9	133.9	126.8	87.0	542.9
"	Ad. ♂ & ♀	15	290.0	253-320	139.7	141.9	125.9	122.7	128.5	121.1	83.2	530.6
M. nemestrinus	Fetus	1	80	.....	47	46	41	52	45	42	36	54
"	Infant	1	117	.....	70	67	60	75	61	59	54	85
"	Juven.	1	249	.....	162	169	147	136	145	141	97	150
"	Adult ♀	1	323	.....	166	173	153	144	154	149	101	171
"	Adult ♂	1	385	.....	210	212	186	175	194	188	123	188
"	Ad. ♂ & ♀	2	354.0	323-385	188.0	192.5	169.5	159.5	174.0	168.5	112.0	179.5

MATERIALS AND METHODS

The data employed consist of measurements on 131 macaques of six different species. The names of the species and the number of specimens of each are given in Table 1.

More than half the total number of specimens (73) are rhesus macaques (*M. mulatta*). These include a series of 32 fetuses, of which 26 have been previously described by Schultz (1937a). The postnatal specimens, all reared in captivity, were obtained originally from dealers' stock imported from various parts of India. They correspondingly exhibit a rather high degree of variability, and possibly include several distinct races. The specimens of *M. philippinensis, M. irus,* and *M. nemestrinus* were with only two exceptions killed in the wild state, the first on a single island in the Philippines and the last two in one locality in Borneo. On the other hand, the individuals of the species *M. sinicus* and *M. speciosus* are all captive, the former emanating entirely from the Carnegie Colony in Baltimore.

The measurements used in the investigation are trunk height, thigh length, leg length, foot length, knee height, upper arm length, forearm length, hand length, and tail length. These are external measurements made on preserved specimens. The technique by which they were obtained has been fully described by Schultz (1929) and need not be repeated here.

Measurements on the outer body are of course less accurate than those made directly on the skeleton. There is nevertheless reason to believe, as will be shown below, that the present ones are sufficiently accurate to be comparable to the corresponding bone measurements. That their reliability is high is indicated by the fact that remeasurement of three of the specimens after an interval of several years yielded values which in no instance differed from the original ones by more than three per cent. The external measurements also offer an advantage in that they permit some measure of trunk size, which is practically impossible to obtain from skeletal material.

The investigation covers the growth of each of the limb segments and the tail in relation to the trunk, and also in relation to other segments. The data were found to be sufficient for an analysis of both prenatal and postnatal relative growth in *M. mulatta,* and of postnatal relative growth in *M. philippinensis.* In each case the measurements were grouped into convenient size classes, and the mean values of these,

TABLE 2

Average lengths of the limb segments and the tail with increasing trunk height (all in mm.) in M. mulatta and M. philippinensis

(The numbers in parentheses under "Tail Length" represent in each case the number of specimens for which the particular average was obtained.)

NUMBER	TRUNK HEIGHT	KNEE HEIGHT	THIGH LENGTH	LEG LENGTH	FOOT LENGTH	UPPER ARM LENGTH	FORE-ARM LENGTH	HAND LENGTH	TAIL LENGTH
				M. mulatta (Prenatal Stages)					
5	17.8	7.0	7.5	5.7	7.2	8.2	6.6	5.5	12.0
4	48.3	21.8	22.1	18.8	21.8	21.8	18.9	16.4	34.3
8	78.9	41.5	39.9	35.4	47.0	38.2	34.6	32.3	69.6
15	103.7	59.2	55.4	51.0	67.9	51.6	47.9	45.2	101.1
				M. mulatta (Postnatal Stages)					
3	136.7	76.7	73.3	68.3	81.3	67.0	61.7	53.7	131.3
3	161.3	87.7	86.3	76.7	92.7	74.0	70.7	60.3	139.3
1	189.0	120.0	113.0	108.0	110.0	103.0	98.0	70.0	173.0
3	224.0	119.0	112.3	104.3	112.0	96.7	92.3	70.3	178.3
5	250.4	138.4	132.4	122.4	128.0	111.6	107.2	78.4	192.8(4)
1	286.0	167.0	159.0	150.0	146.0	133.0	129.0	93.0	223.0
7	320.1	162.9	157.6	146.3	146.9	136.3	131.4	93.6	219.7
11	340.6	168.8	168.7	151.0	149.0	146.3	138.2	96.7	232.5
6	367.5	181.8	179.5	163.7	158.0	151.8	148.3	104.8	260.1
1	396.0	199.0	198.0	180.0	170.0	163.0	158.0	103.0	284.0
				M. philippinensis (Postnatal Stages)					
1	110.0	66.0	62.0	58.0	69.0	61.0	55.0	44.0	262.0
1	180.0	101.0	95.0	90.0	95.0	90.0	80.0	59.0	366.0
4	213.5	120.3	116.0	107.5	111.5	105.5	99.3	71.5	434.8
6	233.8	125.3	121.5	111.7	114.3	110.0	104.3	73.5	450.8(5)
8	251.1	133.0	130.3	118.8	119.4	116.9	110.9	78.0	483.8(5)
5	269.0	139.2	138.6	125.4	126.6	122.2	118.2	84.5	523.8(4)

which are given in Table 2, were used in the analysis. Although it would be desirable to treat the sexes separately, the number of specimens proved to be too small to permit such a procedure. Preliminary plots of all the individual measurements, however, showed no appreciable differences between males and females; hence it was considered justifiable to lump them together.

In six specimens—one of *M. mulatta* and five of *M. philippinensis*—the tail was bitten off or otherwise lost. The number of specimens for which tail length is given is therefore somewhat lower than in the case of the other measurements.

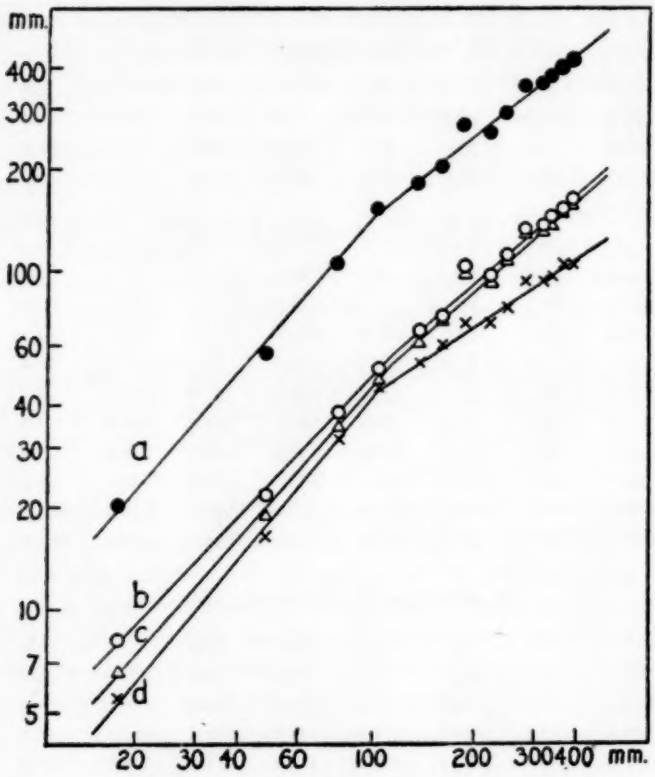

FIG. 1. DOUBLE LOGARITHMIC PLOT OF (a) LENGTH OF UPPER LIMB, (b) LENGTH OF UPPER ARM, (c) LENGTH OF FOREARM, AND (d) LENGTH OF HAND AGAINST TRUNK HEIGHT IN MACACA MULATTA

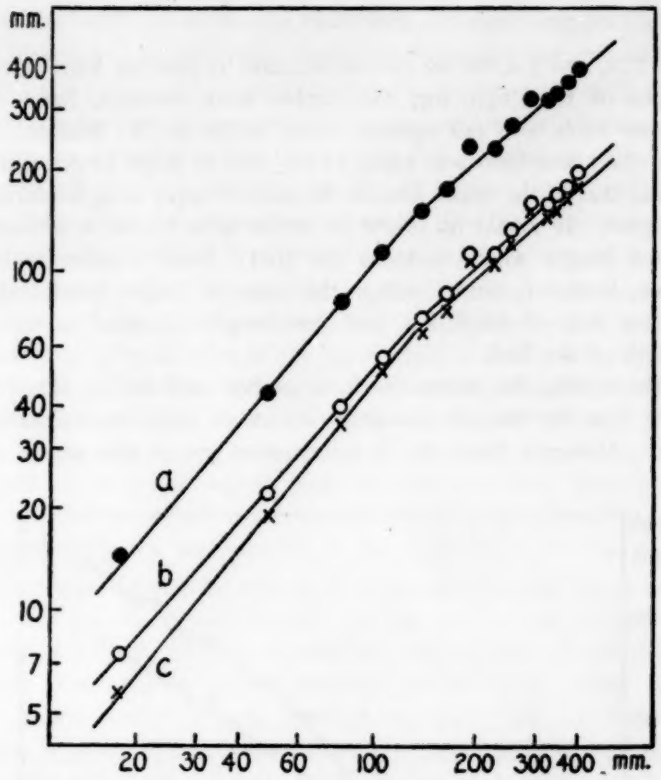

FIG. 2. DOUBLE LOGARITHMIC PLOT OF (a) LENGTH OF LOWER LIMB, (b) LENGTH OF THIGH, AND (c) LENGTH OF LEG AGAINST TRUNK HEIGHT IN MACACA MULATTA

The data for the remaining species are inadequate to permit individual analyses. These were used only for the purpose of determining the average values of the postnatal relative growth constants in all the species combined. For this the values given in Table 1 were employed, in a manner to be described more fully in the next section.

To test the applicability of the law of allometry, the length of one part was plotted against that of another on a double logarithmic grid. If the equation is applicable, the points on such a graph fall along a straight line of slope a and y-intercept $\log b$. The values of these constants were calculated by the regression method of least squares (Feldstein and Hersh, 1935a), and their standard errors by the methods described by Feldstein and Hersh (1935b) and Lerner (1936).

RESULTS

Figs. 1, 2, and 3 show the curves obtained by plotting logarithmically the lengths of the thigh, leg, foot, upper arm, forearm, hand, lower limb, upper limb, and tail against trunk height in *M. Mulatta*. The length of the lower limb was taken as the sum of thigh length and knee height, and that of the upper limb as the sum of upper arm, forearm, and hand lengths. It would no doubt be preferrable to use a measure of lower limb length which includes the foot. Such a measure is unobtainable, however, since neither the sum of thigh, knee and foot lengths nor that of thigh, leg, and foot lengths is equal to the exact total length of the limb.

On the whole, the points conform rather well to the fitted lines, indicating that the law of allometry provides a valid representation of the data. Although there are in some cases one or two points which

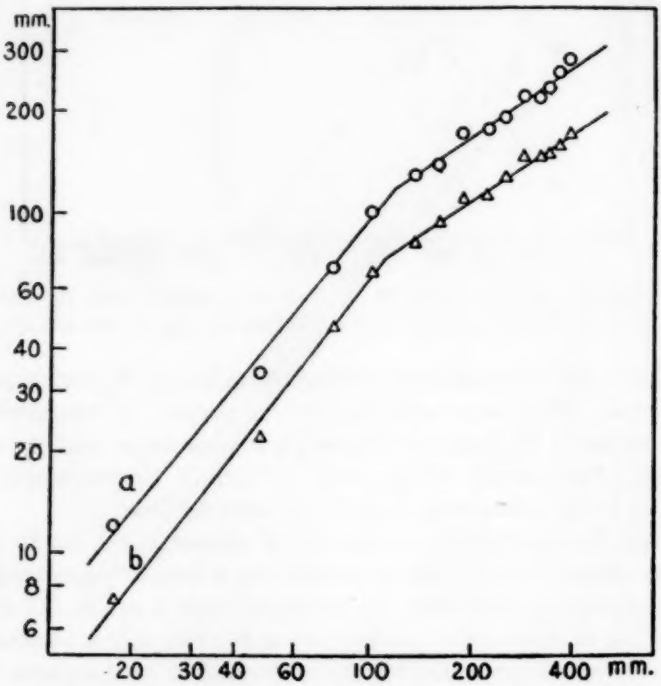

FIG. 3. DOUBLE LOGARITHMIC PLOT OF (a) LENGTH OF TAIL AND (b) LENGTH OF FOOT AGAINST TRUNK HEIGHT IN MACACA MULATTA

deviate markedly from the curves, each of these represents only a single individual; consequently these deviations are not serious.

For each relationship two distinct lines are required to fit the data, the first for the prenatal period and the second for the postnatal. In all instances the break between them occurs at a value of trunk height corresponding approximately to the time of birth. There is thus at this time a sharp change in the growth rates of the limb segments and the tail in relation to that of the trunk.

The values of the constants log b and a for these relationships may be found in Table 3. The constants a, which represents the ratio of the percentage growth rates of the parts y and x, is of particular interest. In the present instance the values of a for the prenatal period are all greater than 1, whereas those for the postnatal period are all less than 1. Hence the percentage growth rates of the limb segments are higher than that of the trunk during fetal life, but are lower after birth. It may be noted here that a similar conclusion was reached by Schultz (1933) through the comparison of size indices.

In the upper limb, the value of a during prenatal development is highest for the hand and lowest for the upper arm. There exists, therefore, a growth gradient extending along the axis of the limb, with the point of the highest growth intensity located in the hand. In postnatal life, the relative growth rates of the upper arm and forearm are approximately equal, and are considerably higher than that of the hand, which exhibits at birth a much greater decrease in the value of a than do the other upper limb segments. The growth pattern in the lower limb completely parallels that in the upper, both before and after birth.

In the upper limb/lower limb relation, the prenatal and postnatal values of a are both greater than 1. These values may be misleading, however, since the measure of lower limb length employed does not take into account the length of the foot. It is evident that the inclusion of the foot would increase the value of a for the prenatal period but would decrease it for the postnatal. Hence during prenatal life the upper limb clearly grows more rapidly than the lower limb, which suggests the possible existence in the trunk of an antero-posterior growth gradient, decreasing posteriorly. On the other hand, it seems doubtful whether there is any significant difference in the growth rates of the two limbs during postnatal life.

It is important to recognize that these gradients, which are derived from average measurements for the group, do not necessarily represent the distribution of growth intensities in each individual. In *Notonecta undulata*, as Clark and Hersh (1939) have shown, the constants calcu-

TABLE 3

Values of log b and a, with their standard errors, for Macaca mulatta

RELATION	LOG b	a
	Prenatal stages	
Thigh/Trunk	−0.5550 ± 0.0093	1.1382 ± 0.0051
Leg/Trunk	−0.8086 ± 0.0093	1.2458 ± 0.0050
Foot/Trunk	−0.7725 ± 0.0425	1.2879 ± 0.0153
Upper arm/Trunk	−0.4058 ± 0.0112	1.0489 ± 0.0060
Forearm/Trunk	−0.6027 ± 0.0123	1.1302 ± 0.0067
Hand/Trunk	−0.7782 ± 0.0174	1.2049 ± 0.0095
Tail/Trunk	−0.4680 ± 0.0284	1.2213 ± 0.0149
Lower limb/Trunk	−0.3192 ± 0.0113	1.1774 ± 0.0062
Upper limb/Trunk	−0.1508 ± 0.0226	1.1535 ± 0.0123
Leg/Thigh	−0.2010 ± 0.0016	1.0944 ± 0.0008
Foot/Thigh	−0.1460 ± 0.0432	1.1326 ± 0.0088
Forearm/Upper arm	−0.1654 ± 0.0002	1.0776 ± 0.0008
Hand/Upper arm	−0.3126 ± 0.0040	1.1491 ± 0.0028
Lower limb/Upper limb	−0.1616 ± 0.0108	1.0190 ± 0.0059
	Postnatal stages	
Thigh/Trunk	−0.0262 ± 0.0376	0.8903 ± 0.0153
Leg/Trunk	−0.0247 ± 0.0494	0.8737 ± 0.0202
Foot/Trunk	0.5233 ± 0.0386	0.6544 ± 0.0126
Upper arm/Trunk	0.0074 ± 0.0414	0.8501 ± 0.0169
Forearm/Trunk	−0.0770 ± 0.0405	0.8766 ± 0.0165
Hand/Trunk	0.3239 ± 0.0245	0.6573 ± 0.0122
Tail/Trunk	0.6758 ± 0.0452	0.6708 ± 0.0170
Lower limb/Trunk	0.3267 ± 0.0412	0.8713 ± 0.0169
Upper limb/Trunk	0.5376 ± 0.0349	0.8074 ± 0.0132
Leg/Thigh	−0.0038 ± 0.0290	0.9837 ± 0.0105
Foot/Thigh	0.5436 ± 0.0843	0.7346 ± 0.0076
Forearm/Upper arm	−0.0806 ± 0.0165	1.0292 ± 0.0079
Hand/Upper arm	0.3307 ± 0.0278	0.7671 ± 0.0145
Lower limb/Upper limb	−0.2503 ± 0.0306	1.0784 ± 0.0125

lated from average values of the measurenments disclose an antero-posterior gradient for the growth of the legs in relation to the growth of the body, with the maximum in the first leg. On the other hand, in the gradients determined for single individuals the maximum lies in the first leg in only about half the cases; in the other half, it generally lies in the second leg. Obviously, in such circumstances the results obtained from averages may be misleading. In view of the variability of *M. mulatta* mentioned above, it is not unlikely that a similar situation may exist in this species. The present data, however, obviously do not permit any analysis of relative growth in individuals.

The tail, like the hand and foot, exhibits a high relative growth rate in prenatal life, followed by a sharp decrease at the time of birth. It is particularly interesting to note that the values of a in all three parts are approximately the same in magnitude.

Figs. 4, 5, and 6 show the curves obtained for the leg/thigh, foot/thigh, forearm/upper arm, hand/upper arm, and lower limb/upper limb

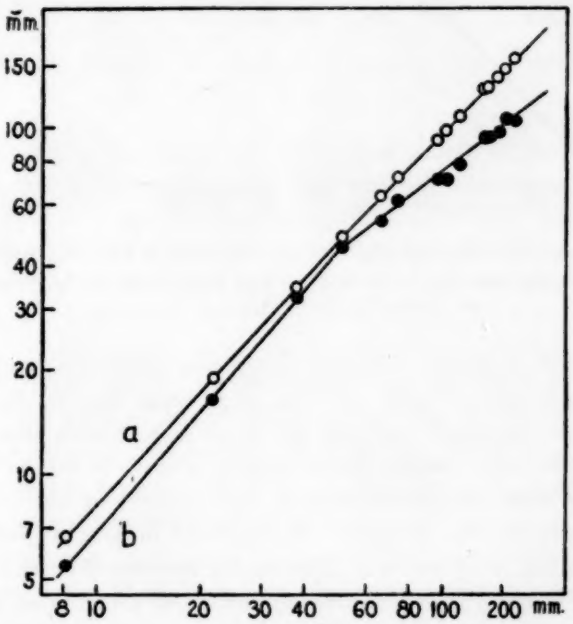

FIG. 4. DOUBLE LOGARITHMIC PLOT OF (a) LENGTH OF FOREARM AND (b) LENGTH OF HAND AGAINST LENGTH OF UPPER ARM IN MACACA MULATTA

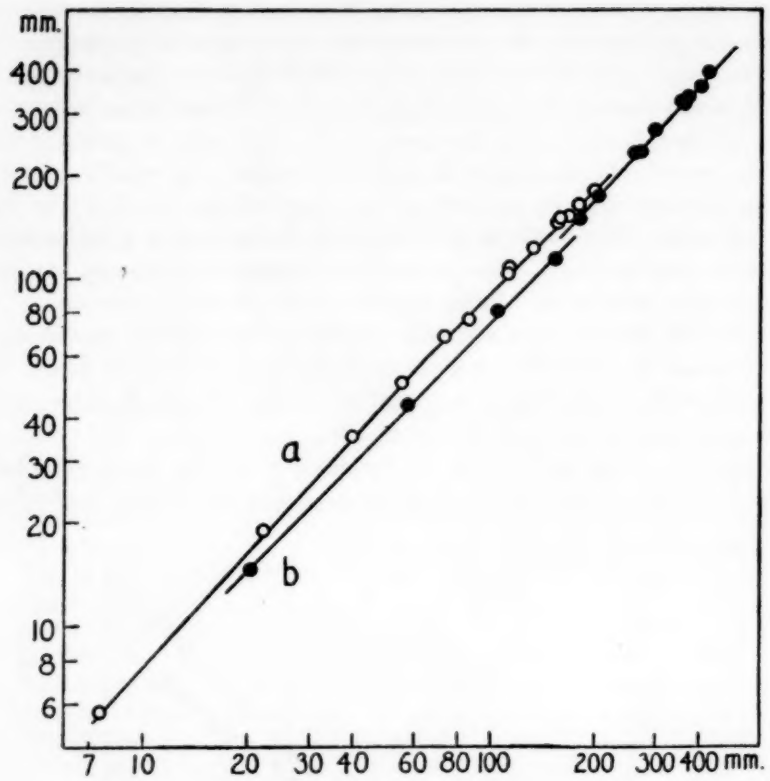

FIG. 5. DOUBLE LOGARITHMIC PLOT OF (a) LENGTH OF LEG AGAINST LENGTH OF THIGH AND (b) LENGTH OF LOWER LIMB AGAINST LENGTH OF UPPER LIMB IN MACACA MULATTA

relations in *M. mulatta*. It may be noted that the fit here is appreciably better than in Figs. 1 and 2. This is probably due to the fact that measurements of single bones are apt to be less variable than measurements such as trunk height, which involve a series of bones.

Each of these curves exhibits, as do the previous ones, a break at approximately the time of birth. In the lower limb/upper limb relation (curve b of Fig. 5), there is a discontinuity between the two fitted lines. This is, incidentally, the only instance in which a increases in value at birth. Although in the forearm/upper arm and leg/thigh relations (curve a of Fig. 4 and curve a of Fig. 5) the break appears so slight as

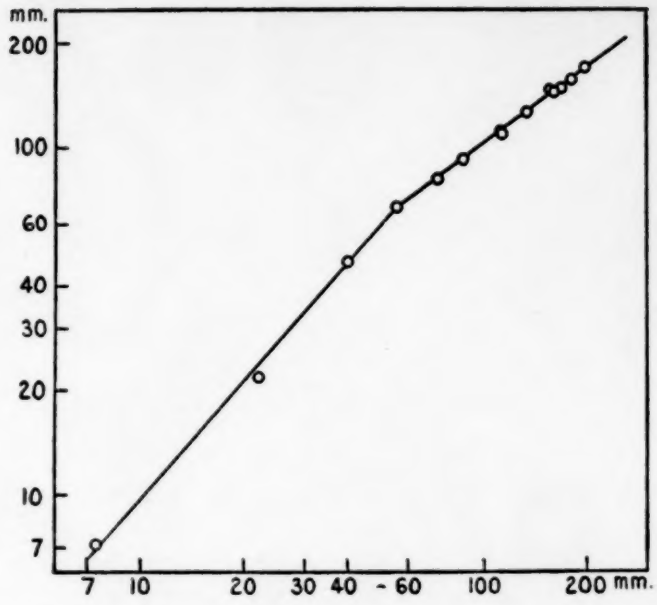

FIG. 6. DOUBLE LOGARITHMIC PLOT OF LENGTH OF FOOT AGAINST LENGTH OF THIGH IN MACACA MULATTA

to be negligible, it is nevertheless valid, as is shown by the fact that in both cases the differences in value between the prenatal and postnatal constants (Table 3) are statistically significant. Hence there occurs at the time of birth a change in the percentage growth rates of the limbs and limb segments not only in relation to trunk height, but also in relation to one another.

In Fig. 7 the lengths of the limbs, limb segments, and tail in *M. philippinensis* are plotted logarithmically against trunk height. The curves in this instance cover only the postnatal period. Considering the small number of specimens, the fit is in general rather good; in fact, the standard errors of log b and a, given in Table 4, are with few exceptions lower than those in *M. mulatta*.

It is of interest to compare the growth relations in *M. mulatta* and *M. philippinensis*. With respect to the limb segments, comparison of the constants in Table 3 and 4 shows that in the upper arm/trunk and hand/trunk relations the differences in both log b and a lie well above

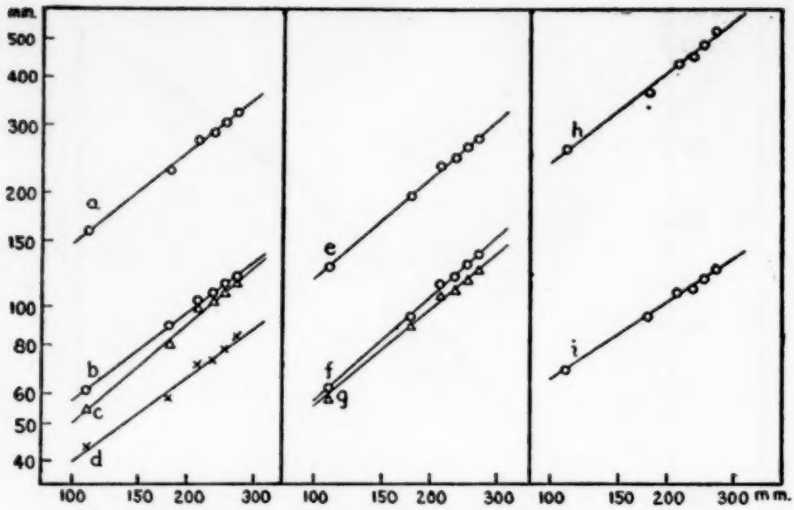

FIG. 7. DOUBLE LOGARITHMIC PLOT OF THE LENGTHS OF (a) UPPER LIMB, (b) UPPER ARM, (c) FOREARM, (d) HAND, (e) LOWER LIMB, (f) THIGH, (g) LEG, (h) TAIL, AND (i) FOOT AGAINST TRUNK HEIGHT IN MACACA PHILIPPINENSIS

the 0.05 level of significance. In the remaining relations, on the other hand, none of the differences are statistically significant.

In the tail/trunk relation, the differences in log b and a are significant and of about the same magnitude as in the upper arm/trunk and hand/trunk relations. This similarity is misleading, however, for whereas in the case of the upper arm and hand the relative growth curves for the two species almost overlap, in the case of the tail they lie a considerable distance apart (see Fig. 8C). This seeming paradox arises from the fact that the value of log b depends on the units in which the structures in question are measured. In the present instance, when the unit of measure is the millimeter, the point on the curve representing log b (i.e., the value of log y when log $x = 0$) is considerably removed from the range covered by the postnatal growth data. At this point the curves for the two species are roughly the same distance apart for all three relations. If the sizes of these parts were measured in a unit which would bring the point representing log b closer to the range of the data, a truer picture would be obtained. Thus, if the measurements are converted to decimeters, the difference in log b for

the upper arm/trunk relation decreases from 0.2171 to 0.0529 and that for the hand/trunk relation from 0.1789 to 0.0340. On the other hand, the difference in log *b* for the tail/trunk relation increases from 0.1637 to 0.3615.

TABLE 4

Postnatal values of log b and a, with their standard errors, for Macaca philippinensis and for all species combined

RELATION	LOG *b*	*a*
	M. philippinensis	
Thigh/Trunk	−0.0247 ± 0.0337	0.8919 ± 0.0142
Leg/Trunk	0.0550 ± 0.0408	0.8424 ± 0.0173
Foot/Trunk	0.4936 ± 0.0384	0.6615 ± 0.0162
Upper arm/Trunk	0.2246 ± 0.0291	0.7680 ± 0.0123
Forearm/Trunk	−0.0089 ± 0.0376	0.8566 ± 0.0158
Hand/Trunk	0.1449 ± 0.0540	0.7298 ± 0.0228
Tail/Trunk	0.8395 ± 0.0466	0.7696 ± 0.0233
Lower limb/Trunk	0.3697 ± 0.0352	0.8549 ± 0.0151
Upper limb/Trunk	0.5933 ± 0.0328	0.7891 ± 0.0139
	All Species	
Thigh/Trunk	−0.0413 ± 0.0417	0.8976 ± 0.0054
Leg/Trunk	0.0174 ± 0.0442	0.8560 ± 0.0057
Foot/Trunk	0.5049 ± 0.0482	0.6574 ± 0.0060
Upper arm/Trunk	0.0345 ± 0.0438	0.8441 ± 0.0057
Forearm/Trunk	−0.0490 ± 0.0467	0.8698 ± 0.0061
Hand/Trunk	0.2700 ± 0.0421	0.6783 ± 0.0055
Lower limb/Trunk	0.3446 ± 0.0408	0.8639 ± 0.0053
Upper limb/Trunk	0.5414 ± 0.0413	0.8086 ± 0.0054
Leg/Thigh	0.0602 ± 0.0218	0.9520 ± 0.0033
Foot/Thigh	0.5392 ± 0.0349	0.7304 ± 0.0053
Forearm/Upper arm	−0.0843 ± 0.0124	1.0303 ± 0.0019
Hand/Upper arm	0.2615 ± 0.0352	0.7944 ± 0.0055
Lower limb/Upper limb	−0.2070 ± 0.0339	1.0577 ± 0.0043
Leg + thigh/Forearm + upper arm	0.0154 ± 0.0337	1.0120 ± 0.0045
Tail/Trunk (*M. nemestrinus*)	0.6344	0.6354
Tail/Trunk (*M. sinicus*)	0.2461	1.0013

This shows that differences in log b cannot generally be used as a measure of the divergence of relative growth curves without taking into account the size of the unit of measurement in relation to the actual range of the data. It suggests, moreover, that if any real significance is to be attached to the value of log b, a unit of measure should be selected such as to make x equal to 1 at the beginning of the growth period in question, in this instance at the time of birth. These considerations obviously do not apply to the constant a, since its value is independent of the unit of measure employed.

In Fig. 8, average values of the measurements on the limb segments and tail in infants, juveniles, and adults of all the species are plotted logarithmically against trunk height. It may be seen that in every instance, with the exception of the tail, the points fall roughly along a single curve. The one point which deviates markedly from each of the curves represents only a single individual.

The values of log b and a, given in Table 4, are very similar to those obtained for *M. mulatta*. This result is clearly to be expected, inasmuch as more than half the specimens involved in the calculation belong to this one species. These constants are therefore not to be regarded as truly representative averages for the group of species in question. The foregoing results suffice to show, however, that relative growth of the limb segments in the various species, despite individual differences, is sufficiently similar to yield, for each relationship, a single curve for the entire group.

The relative growth of the tail presents a very different picture. Here a distinct curve is obtained for each species (Fig. 8C). The curves for *M. sinicus* and *M. nemestrinus* each represent only a small number of individuals; hence their constants must be regarded as merely crude approximations. The values of these constants were calculated by the method of averages. The data for *M. irus* and *M. speciosus* include only adults; these are represented in the figure by the points marked 5 and 6.

The curves for *M. philippinensis* and *M. sinicus* lie fairly close together and converge toward their upper ends, with the point representing *M. irus* lying near the point of convergence. Thus the adults of these three species are very similar with respect to relative length of the tail, their tail/trunk indices being 198.3, 177.6, and 183.0 respectively. The curves show, however, that the course of relative growth is appreciably

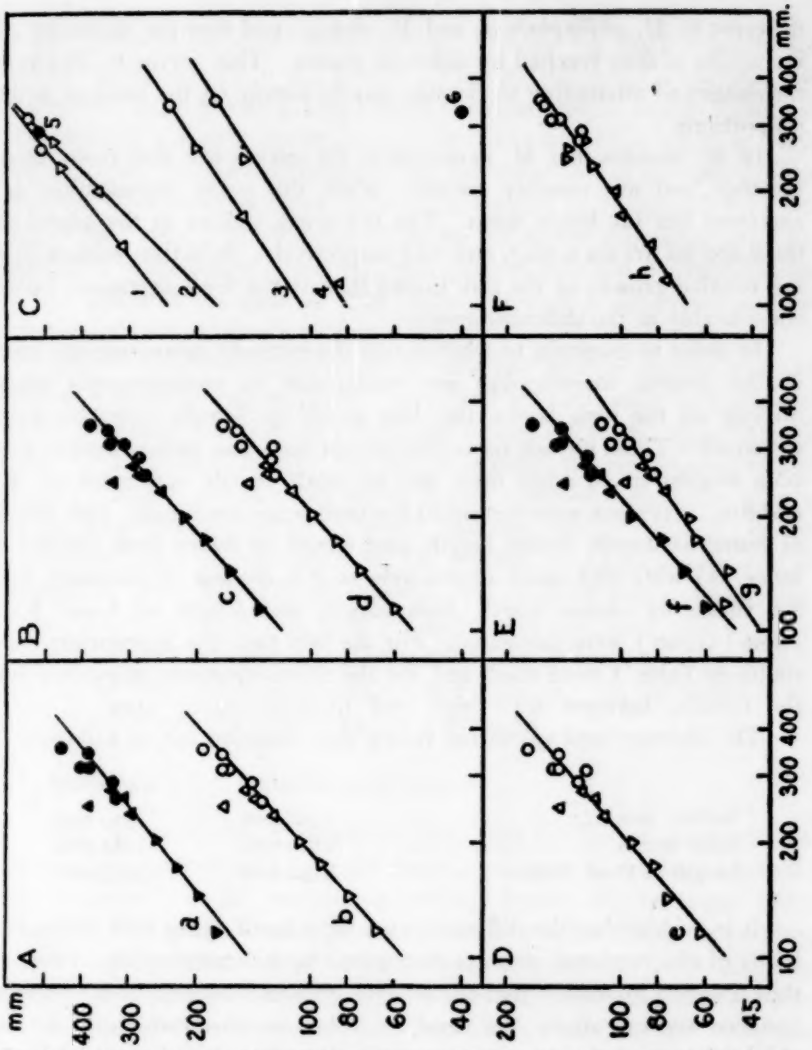

FIG. 8. A, B, D, E, F — DOUBLE LOGARITHMIC PLOT OF THE LENGTHS OF (a) LOWER LIMB, (b) THIGH, (c) UPPER LIMB, (d) LEG, (e) UPPER ARM, (f) FOREARM, (g) HAND, AND (h) FOOT AGAINST TRUNK HEIGHT IN INFANTS, JUVENILES, AND ADULTS OF SIX SPECIES OF MACACA. C — DOUBLE LOGARITHMIC PLOT OF TAIL LENGTH AGAINST TRUNK HEIGHT IN (1) M. PHILIPPINENSIS, (2) M. SINICUS, (3) M. MULATTA, (4) M. NEMESTRINUS, (5) M. IRUS (ADULT), AND (6) M. SPECIOSUS (ADULT)

different in *M. philippinensis* and *M. sinicus,* and that the similarity of the adults is thus reached by different routes. This serves to illustrate the danger of attempting to classify species simply on the basis of adult proportions.

In *M. mulatta* and *M. nemestrinus* the curves are also fairly close together and are roughly parallel, while the point representing *M. speciosus* lies far below them. The tail/trunk indices in the adults of these species are 69.1, 50.7, and 12.7 respectively. It is thus evident that the relative growth of the tail, unlike that of the limb segments, varies considerably in the different species.

In order to ascertain to what extent the external measurements used in the present investigation are comparable to measurements made directly on the limb bones, the data given by Schultz (1937b) were employed. These include measurements of humerus, radius, femur, and tibia lengths in 19 adult male and 60 adult female specimens of *M. mulatta.* Averages were computed for both sexes combined. The values of humerus length, femur length, and length of lower limb (radius+humerus) were then taken successively as x in the law of allometry, and the values of radius length, tibia length, and length of lower limb (tibia+femur) were calculated. For the first two, the appropriate constants in Table 3 were used, and for the third, constants calculated for the relation between leg+thigh and forearm+upper arm.

The observed and calculated values thus obtained are as follows:

	Observed	*Calculated*
Radius length.....	135.6 mm.	133.1 mm.
Tibia length.....	150.0 mm.	148.9 mm.
Length of lower limb.....	313.2 mm.	312.5 mm.

It is evident that the differences are very small, lying well within the limits of observational error as determined by remeasurement. There is thus a strong indication that the relative growth constants in the present instance are essentially the same in value as those which would be obtained from skeletal measurements, and further that they are directly comparable with constants actually so obtained in other primates.

A comparison of the constants for all species combined (Table 4) with those previously obtained by Lumer (1939) for the anthropoid apes shows that the postnatal growth pattern in the limbs of the macaques does not resemble that in any of the anthropoids. The values of log b and a for the forearm/upper arm relation are most similar to

those in the orang-utan, whereas those for the leg/thigh relation are closest to the values in the gorilla. For the relationship between the lower limb and upper limb (leg+thigh/forearm+upper arm in Table 4), the value of α approximates that in the orang-utan, but log b is much higher, lying in the neighborhood of the value in the gibbons. Thus the low intermembral index in adult macaques as compared with the anthropoid apes (Schultz, 1937b) is, so far as the Pongiidae are concerned, a consequence primarily of a difference in the relative lengths of the limbs at the time of birth, rather than of a difference in their relative growth rates in postnatal life.

It has been shown in a number of instances that for a given relationship in a series of related types, b conforms approximately to a decreasing exponential function of α (see, for example, Hersh, 1934; Hamai, 1938, 1939; Lumer, 1939). On the other hand, the results obtained by Lumer (1940) indicate that for a set of different relationships in a single type the conformity is much less clear-cut. Similarly, in the present instance the constants for the growth of the limb segments in relation to trunk height in *M. mulatta,* both prenatal and postnatal, conform only very roughly to such a function; in fact, on a plot of log b against α the points show a considerable degree of scatter. The same is true of *M. philippinensis* in even greater measure. On the whole, however, b tends roughly to decrease as α increases.

DISCUSSION

The results of the investigation show that the law of allometry is a satisfactory approximation to the growth relations in the limb segments of macaques. In *M. mulatta,* a striking feature is the break which occurs in each of the relative growth curves at a value of x corresponding approximately to the time of birth. Presumably the curves for the other species would exhibit similar breaks if they were extended into the prenatal period. Whether or not such breaks are "real", in the sense that there is an actual discontinuity in the slope of the curve, it is impossible to say. It is clear, nevertheless, that they indicate a relatively sudden and marked change in the relative growth rates of the parts concerned.

Apparently a smiliar sharp change occurs in human development. Thus the figures presented by Davenport (1935) show that the brachial index increases rapidly up to the time of birth, then decreases throughout most of postnatal life; also that the intermembral index decreases

very rapidly during prenatal development, but much more slowly after birth. The same thing is shown by a comparison of estimates of prenatal and postnatal values of α in man, the former obtained from the percentage growth rates of the limb segments given by Schultz (1926), and the latter from certain unpublished data. These show, for example, that the value for the forearm/upper arm relation decreases from 1.02 to 0.88 and that for the leg/thigh relation from 1.06 to 0.95. It would be of interest to know whether such differences in prenatal and postnatal relative growth occur also in the anthropoid apes, but unfortunately the available data are too meager to permit even a rough estimate for the prenatal stages.

The relative growth curves of the limb segments in all the species combined, shown in Fig. 8 above, are the same in nature as those obtained by Lumer (1939) for the Hylobatidae. There the question was raised of whether or not the occurrence of a single curve for the entire group indicates that the growth relations are identical in all the species involved. The present results show that this is not necessarily true, that is, that statistically significant differences may exist between the relative growth constants in different species of such a group. In this sense the group constants are, as Hamai (1938) maintains, merely averages. The observed differences, however, are small, and the species of *Macaca* under consideration may therefore be regarded as constituting a fairly homogeneous group with respect to the growth pattern in the limbs.

The law of allometry has been found to apply not only to ontogenetic relative growth, but also, in a number of instances, to the variation in proportions in adults of related types which differ in absolute body size (see Hersh, 1934; Lumer, 1940). That is to say, when the sizes of certain parts in such a series of adults are plotted logarithmically, the resultant points fall along a single straight line. For any group of subspecific rank in which this is true of all relationships, Lumer (1940) has proposed the term *allometric tribe*. It is evident that such a tribe will be constituted whenever the forms composing the group are essentially alike in their ontogentic growth relations, and that within the tribe differences in adult proportions will in that case be due primarily to variation in adult body size rather than in relative growth. The term *allometric tribe* need not, of course, be restricted to subspecific groups.

In the present case, the differences in relative growth of the tail show that the genus *Macaca* does not constitute a single tribe, but is

divisible rather into several such groups. There appear to be at least five, the first containing *M. philippinensis*, the second *M. sinicus* and probably also *M. irus*, the third *M. mulatta*, the fourth *M. nemestrinus*, and the fifth *M. speciosus*. In view of the small number of specimens of some of the species, this subdivision is of course only tentative. Moreover, the number of species included in the investigation is too small to permit any determination of the exact number of tribes. The observed differences seem sufficiently great, however, to make it appear unlikely that the inclusion of further data would necessitate any extensive modification of these conclusions.

Elliot (1913, Vol. II, pp. 188 ff.) divides the genus into six subgenera, mainly on the basis of adult tail length. This classification, together with the position of each of the species included in the present study, is as follows:

1. *Inuus* — contains two groups, one with tail 1½-3½ inches long, the other with tail 3½-8 inches long. *M. speciosus.*
2. *Nemestrinus* — tail not under 8 inches nor over 12 inches. *M. nemestrinus, M. mulatta.*
3. *Vetulus, Zati, Neocebus* — all with tail over 12 inches but not as long as head and body. *M. sinicus.*
4. *Macacaus* — tail equal to or exceeding the head and body in length. *M. irus, M. philippinensis.*

It is evident that this classification corresponds in large part to the division into allometric tribes suggested by the present analysis. There are, however, certain obvious differences. First, whereas Elliot places *M. mulatta* and *M. nemestrinus* in the same group, the difference in their relative growth indicates that they should more properly be placed in separate groups. Second, *M. sinicus* here exhibits a much higher tail length than that given by Elliot for this species. Although the present value is based on only four adult specimens, the difference is so great that it seems extremely doubtful whether the inclusion of a greater number would materially change the situation. The separation of *M. sinicus* from *M. philippinensis* and *M. irus* proposed here is based entirely on a difference in the course of relative growth. On the basis of adult proportions alone, the three species would be grouped together.

These results, though highly tentative, tend to support the notion, suggested by the results of Hersh (1934) on the titanotheres and Lumer (1940) on the domesticated dog, that these tribes, based on differences in

allometry, are valid taxonomic categories. They suggest further that this method may yield a more accurate classification of the genus *Macaca* than that proposed by Elliot, which involves only adult proportions. A broader investigation, including a greater number of specimens and a wider range of species, would therefore be of considerable interest and importance.

SUMMARY

The relative growth of the limb segments and tail in certain species of macaques conforms to the law of allometry $y = bx^a$. In *M. mulatta* the values of a for the various limb segments and the tail in relation to trunk height are all greater than 1 in the prenatal period and less than 1 in the postnatal. Values of log b and a obtained from postnatal relative growth of the limb segments in *M. philippinensis* differ significantly in some instances from the corresponding values in *M. mulatta*. Nevertheless, when average values for all the six species included in the investigation are plotted together, the points fall approximately along a single curve, showing that the growth pattern in the limbs is essentially similar in all these species. The growth pattern in the limbs of macaques does not, however, resemble that in any of the anthropoid apes.

The relative growth of the tail varies greatly in the different species. These differences suggest that the genus is tentatively divisible into at least five allometric tribes, the members of each being essentially alike in their relative growth. These correspond for the most part to the subgenera in Elliot's classification.

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INDIVIDUAL GROWTH-RATES*

FROM BIRTH TO MATURITY FOR 15 PHYSICAL TRAITS

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INTRODUCTION

IN learning about the growth of children, as about most subjects, science has begun with general orientation based on averages or the mass method. In these terms knowledge has developed with the years, proceeding from large and often indiscriminately mixed material to smaller and more homogeneous groups.

Long range of each individual's record. Of recent years, both for the pursuit of pure science and for the purposes of patients, increasing attention has been focussed on the longitudinal method. This method, being dependent on the tedious accumulation of observations on an individual child followed over many successive years, is still in its infancy. The span covered in most series has seldom amounted to eight years out of the whole active growth period of two decades. The material here to be reported is very special in that it covers the span from birth to maturity.

Large number of traits. Most material covers only weight and height, rarely half a dozen physical traits. The present material covers 15 traits.

Rates vs. absolute size. In recent years greater interest has been taken in rates of growth. Whereas a curve plotted from absolute measurements, even on a large scale, reveals rather vaguely the fluctuations in growth, it has been found that these changes in the speed of growth can be manifested much more clearly if from the original data rates are

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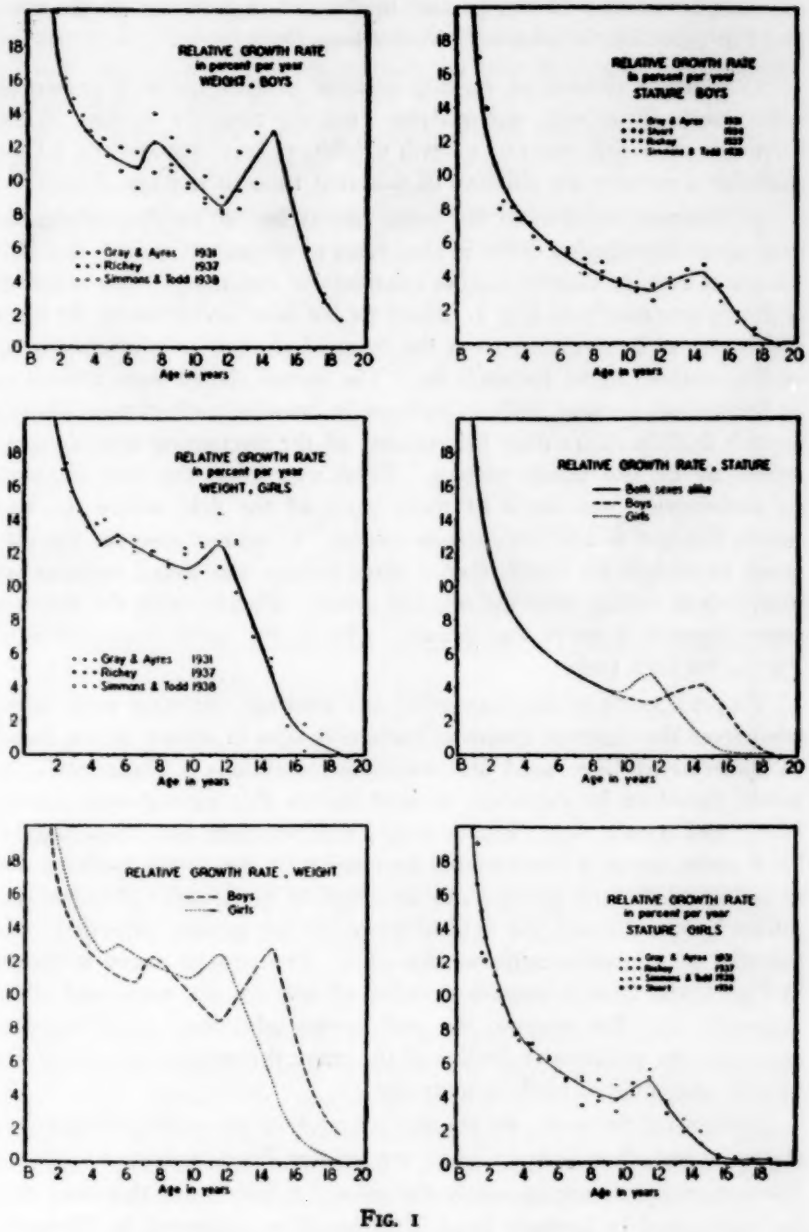
RELATIVE GROWTH RATE
in percent per year
WEIGHT, BOYS
Gray & Ayres 1931
Richey 1937
Simmons & Todd 1938
Age in years
RELATIVE GROWTH RATE
in percent per year
STATURE BOYS
RELATIVE GROWTH RATE
in percent per year
WEIGHT, GIRLS
Gray & Ayres 1931
Richey 1937
Simmons & Todd 1938
Age in years
RELATIVE GROWTH RATE, STATURE
Both sexes alike
Boys
Girls
Age in years
RELATIVE GROWTH RATE, WEIGHT
Boys
Girls
Age in years
RELATIVE GROWTH RATE
in percent per year
STATURE GIRLS
Age in years

FIG. 1

calculated. Besides clarity, greater usefulness, at least for those interested in precision, is inherent in rates because:

1. Whereas childen of varying national origins are well known to differ markedly in size, our analyses (not reproduced) of data in the literature show that rates of growth exhibit, at least for stature, a considerable constancy for children of different races at any age chosen.

2. Whereas children of the same nation but of varying economic-geographic distribution differ in size, rates of growth in weight, and also stature at any age chosen, exhibit considerable constancy. The evidence is shown graphically in Fig. 1. Here we see how satisfactorily the rates which we have calculated from the original absolute measurements by various authors agree for each sex. The curves shown were arrived at by letting two persons, with experience in drawing such curves, smooth in with flexible rulers their impressions of the fluctuating trends represented by all the points plotted. Then over-lying the two tracings, an examination was made of those parts of the field where the two curves diverged to any considerable extent. If neither observer felt disposed to change his trend, then a third person was asked to make an independent tracing over the original points. Finally, with the tracings super-imposed, a curve was drawn. This is the curve, represented in Fig. 1, for each trait.

To get a graph of the changes of rate with age, the rates were calculated from the observed means at successive ages in several series, based on material of like racial and economic conditions. These rates, as would therefore be expected, showed curves that agreed very closely (Gray and Ayres, 1931; Richey 1937; and Simmons and Todd, 1938). Each series shows a considerable fluctuation of the points, perhaps due to biological factors, perhaps due to sampling variations. A curve was drawn by eye through the field to represent the general growth in this material of unusually uniform character. The general curve is shown in Fig. 1, and from it numerical values of rate for age were read off in Appendix A. For stature, the well-known adolescent acceleration is seen; also the progressive decline of the curve throughout the rest of the growth period from birth to maturity.

Comparing the sexes, we see that the adolescence occurs, as expected, earlier in girls than in boys. Also we see that from birth up to 9 years, the stature curves are so nearly the same for both sexes that they may be represented by a single line. This has been suggested by Simmons

and Todd and is worthy of emphasis, particularly as it is absent in many characteristics; for example, weight. After the age of 9, stature shows the well-known pubertal spurt, reaching its peak in girls at 11 years, and in boys at about 14½ years.

The effect on growth of early, average and late puberty will not be gone into in this paper beyond showing in Fig. 2 a chart made of both

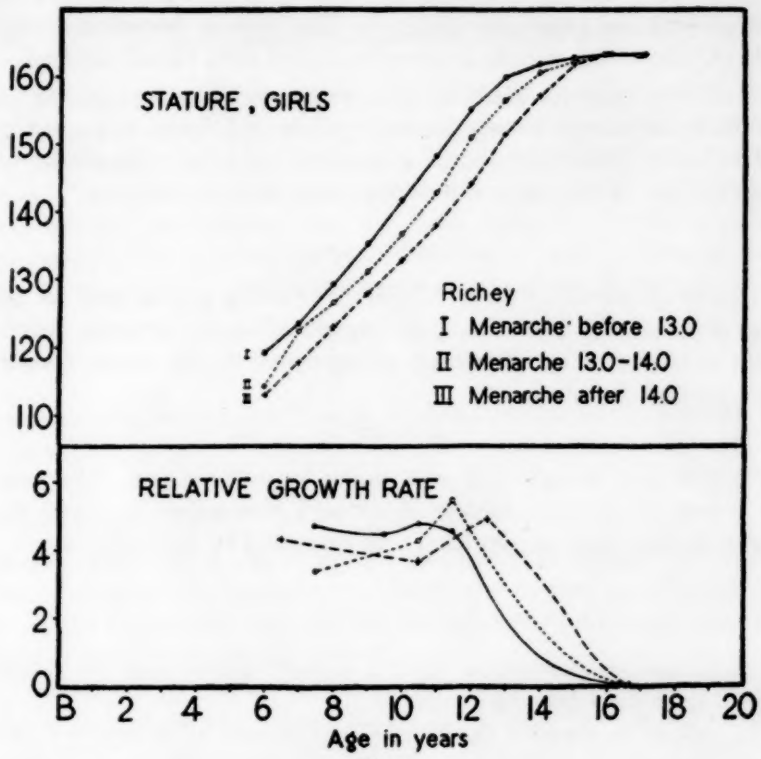

FIG. 2

absolute size and of growth rates calculated from Richey's material. The pubescent spurt in rate is beautifully clear, and occurred earlier than the age of menarche; that is, for girls whose periods started before 13.0 years, the most rapid rate of growth of stature fell at 10½ years; for those with menarche between 13.0 to 14.0 years, the most rapid rate was at 11.5 years; and for those whose menarche began after 14.0 years, the most rapid rate averaged to be at 12.5 years.

For weight, the curves do not coincide. The rates for girls were higher at practically all ages up to the peak of the pubertal acceleration, which for weight was in girls at 11½ years; after this point the rate fell rapidly below the boys' curve. It will be noticed that the juvenile spurt is very conspicuous for both sexes, and, as with the pubertal spurt, occurred about two years earlier in girls than in boys.

3. In sum, therefore, instead of needing a different standard for each national and geographic group, we may hope to determine a single table of rates which may be a master standard valid for all children.

4. In particular the study of rates was undertaken here in order to test the hypothesis previously discussed (Gray and Ayres, 1931, p. 187) that a definite juvenile acceleration in growth takes place in children at about the age of six years, at least for some physical traits.

METHOD OF RATES

Choice of rate to be used. The term "relative growth rate" in this paper is not used to mean simply the growth of a part (or trait) relative to the total size of the individual, as expressed by the power formula (Huxley and Teissier)

$$y = bx^a$$

which plots as a straight line on a double logarithmic grid. We mean the growth of the trait relative to its own momentary size, and also relative to time (per annum basis), as expressed by the formula

$$\frac{1}{y}\frac{dy}{dt} \times 100,$$

the instantaneous percentage rate; a concept which may be readily grasped from the following expansion.

In seeking to simplify the infinite complexities of growth we need not be discouraged by the progressively intricate methods of analysis. Sundry schemes have served up to a certain point of development, then further study indicates supplementary devices. For example, there are:

1. Magnitude m at given age, say in millimeters,

2. Magnitude in percentage of magnitude at initial age reported,

3. Magnitude in percentage of magnitude at preceding birthday,

4. Magnitude in percentage of magnitude at maturity (not in the sense of puberty but in the sense of prime or adulthood),

5. Increment dm for given period, e.g., per year, in mm.,

6. Increment for given period in percent of magnitude at last birthday; i.e., some improvement on the arithmetic rate,

7. Increments per unit time per momentary magnitude, $\frac{1}{m}\frac{dm}{dt}$, i.e., instantaneous relative rate,

8. Percentage increments per unit time per momentary magnitude $\frac{100}{m}\frac{dm}{dt}$, the instantaneous percentage rate. Meredith, 1935, on plotting his measurements directly (integral curves) found that "only head length and breadth approximate the exponential form. Consequently the logarithmic method is rejected as not being valid for use in this study". He proceeded to use the arithmetic method, though its inferiority to the instantaneous rate had been explicitly pointed out, both theoretically and numerically, by Fisher, 1921, and by Brody, 1927. The former wrote: "The relative growth rate at any instant is

$$\frac{1}{m}\frac{dm}{dt} = \frac{d}{dt}\log_e m$$

where m is the mass and t the time; and may be calculated from any two observations:

$$R = \frac{\log_e m_2 - \log_e m_1}{t_2 - t_1}$$

where the suffixes 1 and 2 indicate the first and second observations. This gives correctly the average value of the relative growth rate over the period between the two observations, whatever may be the nature of the changes in rate over this period".

Advantage of the instantaneous percentage rate. It is satisfying always to find on plotting age-means for a trait that the curve looks exponential, or otherwise suggests that after some transformation the rate will plot linearly or be constant, at least over a period of years (as observed by Brody). Nevertheless, we have considered Fisher's remarks sufficient warrant for applying the method to the study of rate-changes of growth in dwarfs (Bayer and Gray, 1937), and note the following advantages which the method may have:

1. Time unit is standard: Though intervals between observations on patients are rarely uniform, instantaneous rates are at once referable to a time-unit, for which we prefer the year.

2. Base of percentage is standard: Though, for the adolescent patient complaining of retarded or excessive growth, the past size at birth is seldom known (except for weight) and the future size at maturity is never known, the instantaneous mass and instantaneous rate afford a standard base.

3. Body parts and proportions are standard: Though measurements of varying parts of the body be of different magnitudes and therefore hard to compare, instantaneous rates permit the parts to be directly compared.

4. Extrinsic influences are standardized: Though the magnitude of a trait at any age varies by sex, race, economic condition, as remarked in the introductory paragraphs of this paper, rates under these varying conditions might prove constant. This would be a valuable simplification.

5. Detection of changes are facilitated: Though absolute size of a trait progresses from age to age, the size curxe may fluctuate so little that changes can be detected with difficulty, while a curve for the instantaneous rate will manifest conspicuous changes.

6. Reality of apparent changes: "In considering a prediction it is safer to have before one's eyes the fluctuating growth rates of the past than the deceptively smooth curve resulting from their cumulation". (Hotelling, 1927).

7. Interpretation of changes: "In dealing with causes which manifest themselves as tendencies amid fluctuations the differential method (instantaneous rate) has marked logical advantages (over the integrated size)." (Hotelling, 1927).

Smoothing of published means. Averages (say of stature) for any sex-race-economic group, plotted for successive ages, generally exhibit fluctations. These are partly due to small numbers of children in the group observed, and, therefore, we believe should be smoothed within the limits of calculated errors of sampling in order to minimize this factor as a cause of rate-changes which otherwise would be irregular by accident of sampling rather than by significance. Such adjustments, cautiously made, are of small degree, turning out to be of the order of only 1 or 2 per cent of the reported mean. This procedure contributes considerably to clarity for generalization, and at least is more unbiased than smoothing the subsequently calculated rates.

Computation of instantaneous relative percentage growth-rate. From the smoothed means, as read from the curve graphically fitted in the preceding paragraph, the percentage rates were then derived by the logarithmic method. In principle, one takes the increment during a given period measured as a decimal fraction of a year, divided by that fraction to get the rate in millimeters per year, and divided again by some value assumed to represent, say, the stature, and finally multiplied by 100. That assumed value has been taken by some as the stature at the beginning of the period. It would be better to take stature as at the middle of the year; or more accurately still, the whole procedure is carried out with logarithms to the base e, as is done throughout the present paper. A paradigm is shown in Table 1; the last two items, 7.9 mm. growth in height per annum, centered at 4.48 years, are plotted in Figure 3, (right lowest panel), showing plainly the juvenile acceleration already mentioned.

TABLE 1

Method of computing instantaneous growth-rate for girl J. G.

DATE	AGE IN YEARS, A	STATURE IN MM, S	$\ln(S/1000)$	$d\ln$	dA	$100\frac{d\ln}{dA}$ = RATE	MIDPOINT OF AGE PERIOD IN YEARS
12-1-25	3.981	1044	.04306	.....	....	....	....
.....	....	....	.....	.07916	1.001	7.91	4.48
12-5-26	4.982	1130	.12222	.....	....	....	....

Smoothing rates. For each trait, the instantaneous rates calculated for various age-periods were plotted, and a smooth curve was drawn through the field. From that diagram again smoothed rates were then read off and listed in Appendix A for girls and in Appendix B for boys. These then form the general basis for any comparisons desired with regard to a particular individual on whose growth one may be able to secure a long period of observations. Specifically, in this paper, they are shown by the heavy curves for norms in the diagrams.

Smoothing of individual measurments and rates. After rates were calculated from the original observations and plotted, it was found in a

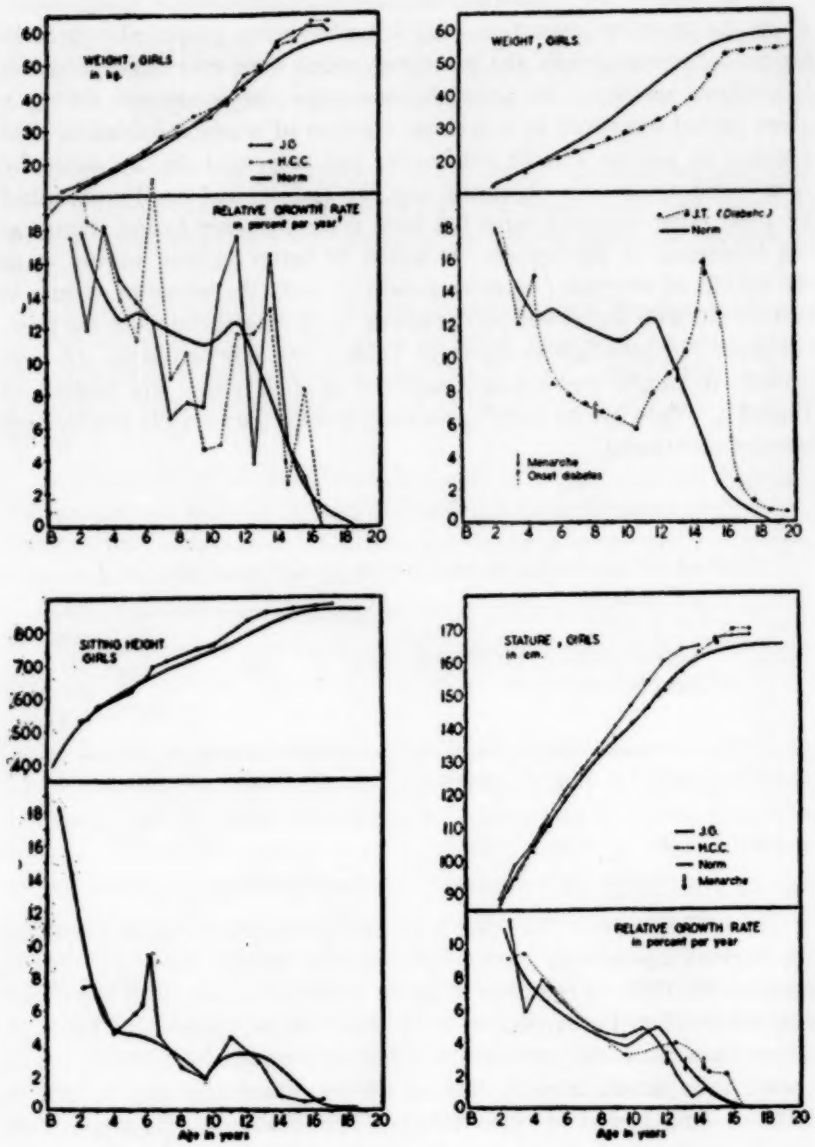
WEIGHT, GIRLS
in kg.
J.G.
H.C.C.
Norm
RELATIVE GROWTH RATE
in percent per year
WEIGHT, GIRLS
J.T. (Diabetic)
Norm
Menarche
Onset diabetes
SITTING HEIGHT
GIRLS
STATURE, GIRLS
in cm.
J.G.
H.C.C.
Norm
Menarche
RELATIVE GROWTH RATE
in percent per year
Age in years
Age in years

FIG. 3

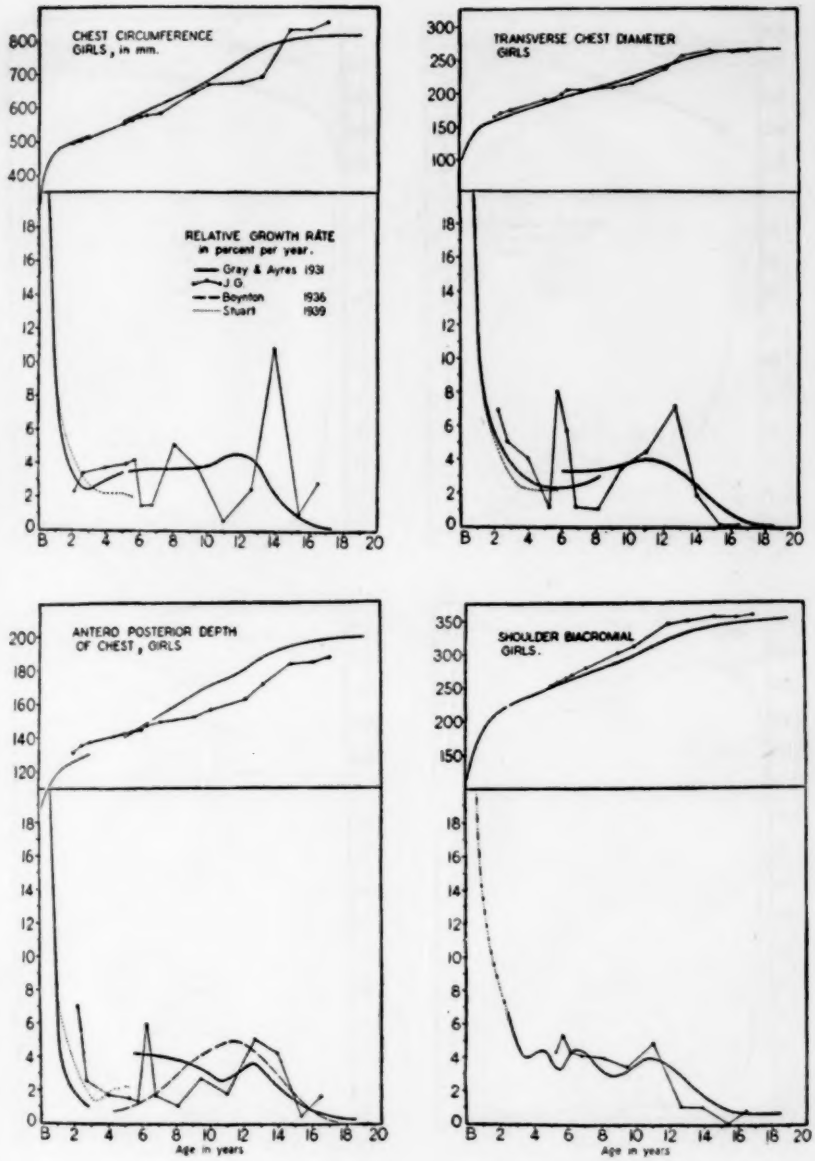
CHEST CIRCUMFERENCE GIRLS, in mm.
RELATIVE GROWTH RATE in percent per year.
Gray & Ayres 1931
J.G.
Boynton 1936
Stuart 1939
TRANSVERSE CHEST DIAMETER GIRLS
ANTERO POSTERIOR DEPTH OF CHEST, GIRLS
SHOULDER BIACROMIAL GIRLS.
Age in years
Age in years

FIG. 4

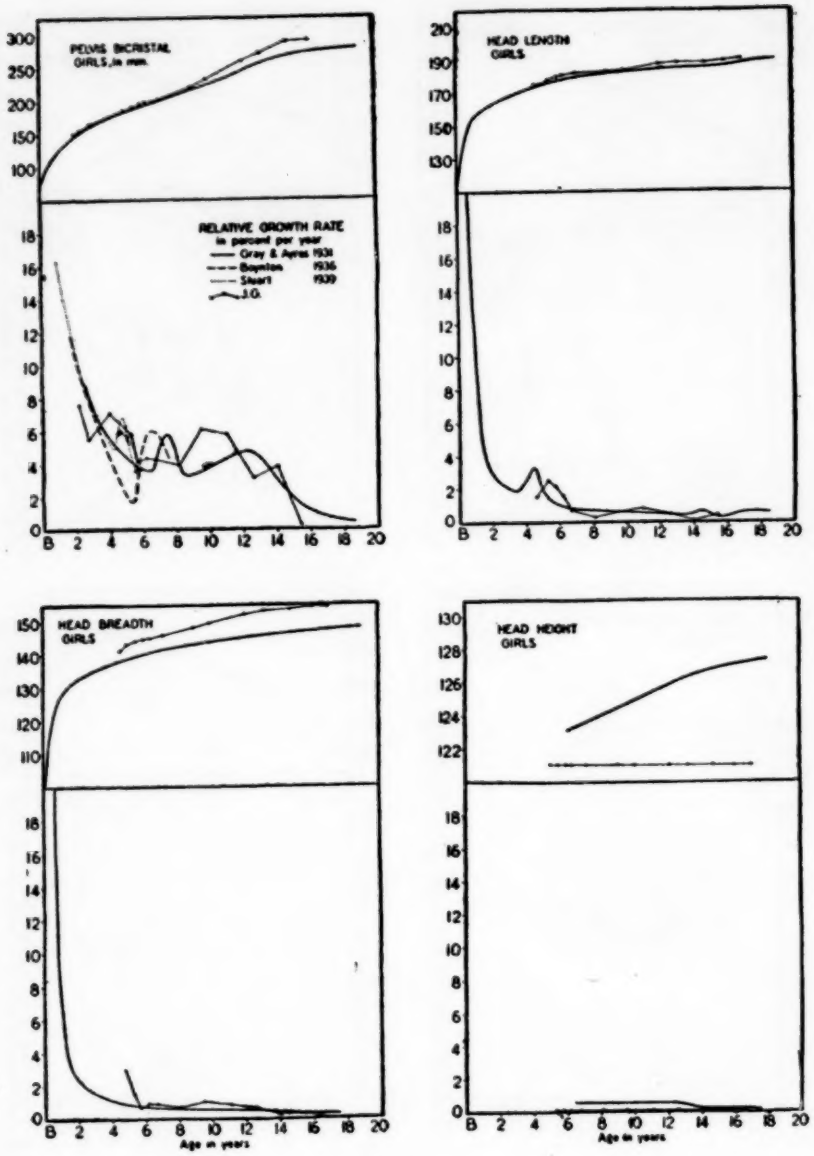
PELVIS BICRISTAL
GIRLS, in mm.
RELATIVE GROWTH RATE
in percent per year
Gray & Ayres 1931
Boynton 1936
Stuart 1939
J.G.
HEAD LENGTH
GIRLS
HEAD BREADTH
GIRLS
HEAD HEIGHT
GIRLS
Age in years
Age in years

FIG. 5

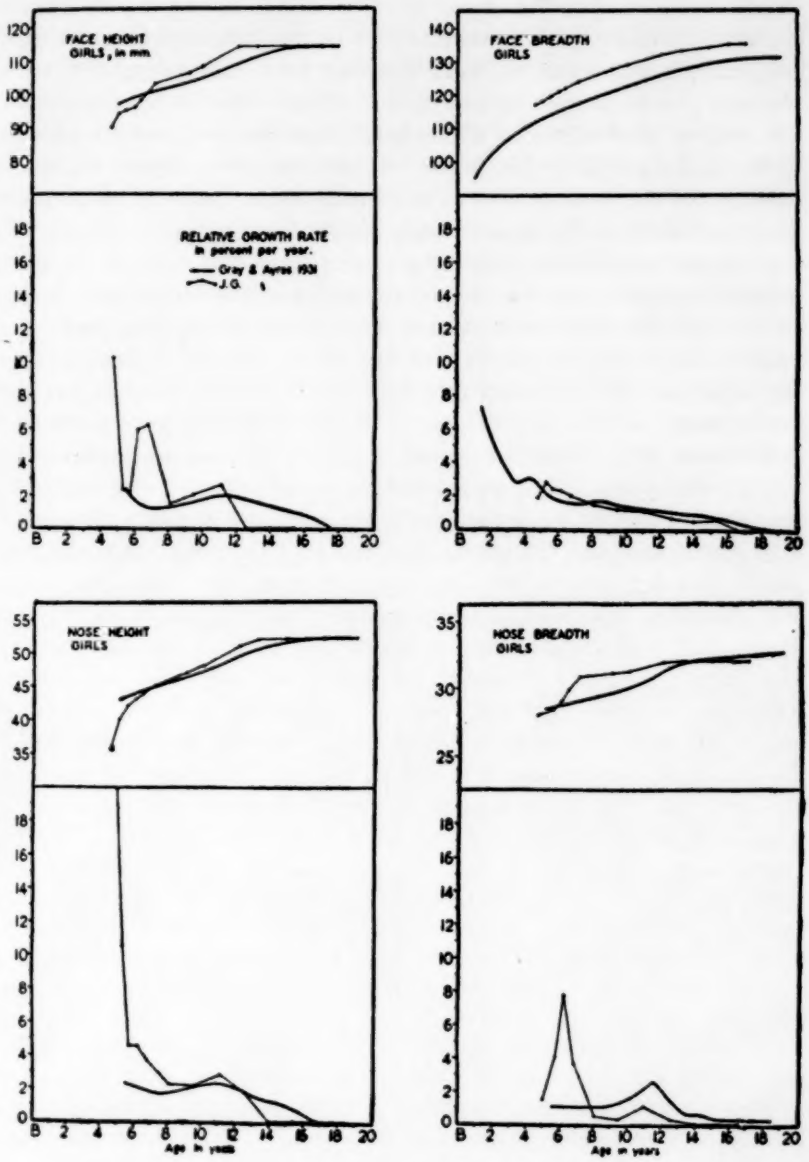
FACE HEIGHT
GIRLS, in mm
FACE BREADTH
GIRLS
RELATIVE GROWTH RATE
in percent per year.
Gray & Ayres 1931
J.C.
NOSE HEIGHT
GIRLS
NOSE BREADTH
GIRLS
Age in years
Age in years

FIG. 6

number of traits that the curves were of such a zig-zag nature as to be extremely confusing. On reinspection of the original observations, it was noticed that some of them deviated from the general course of absolute growth to such an extent as to throw doubt on the accuracy of the original observations. The original observations were not changed in the basic appendix table, but on the plot they were shifted slightly in direction of the general trend of absolute growth. Many of these shifts were calculated and compared with the standard deviation of the trait for normals of the same age, and care was taken that none of the shifts should be greater than this normal variability of the individual. It may be asserted that such shifts on the plots constitute an illegitimate procedure. In defense it can be said that in no case was a shift made if the result on the calculated rate was to produce a swing in the rate curve where none existed before. The rates resulting were plotted for publication only when the result of the shift was to produce less exaggerated peaks. Now we are seeking to detect trends of growth, and we wish to insist on the sudden and severe ups and downs of the growth rate when computed for short intervals, with the result that too great detail does not always help but often obscures the underlying trend. For evidence, reference is made to the published graph (Gray and Bayer, 1937) of stature rates on one of the children recorded here, J. G.; though carefully followed for years, her rates for short-terms (quarter- or even half-year periods) fluctuated without imaginable cause, but when calculated at about yearly intervals became intelligible. Hence, to pick out trends, it is judged not only legitimate but desirable to carry out the manipulations described, provided the result is to remove the minor fluctuations and not to exaggerate any peaks. Particularly with regard to the hypothetical juvenile peaks, care has been taken that none such should be artificially produced by the adjustments described.

GIRLS

Weight. Now, taking up our individual material, we see in Fig. 3, the values for two normal girls. The absolute weights have been reported, together with a discussion of methods of prediction of future size, in a recent paper (Faber and Gray, 1940). In the present paper we show a simplified curve for those absolute weights; but furthermore, in the lower part of the diagram are added the relative rates. The individuals show much more plainly than do the normal curves, both

the pubertal and the juvenile accelerations. In each of these stages the child with the later menarche (H.C.C.) manifests the later acceleration in growth, precisely analogous to the results for groups of girls of differing menarcheal age shown in Fig. 2.

The diabetic child, J.T., shows the juvenile peak at the normal age, about 4.5 years; while, consequent to onset of diabetes, her menarche was slightly late and so was her pubertal spurt in stature.

Stature. (Fig. 3) This is an extraordinarily illuminating graph. Both the normal girls show both early and late spurts. Again it is patent that the girl whose menarche occurred earlier than the average of private school girls had the earliest acceleration in stature rate, at 10.5 years; that the heavy line for the normal average had its peak at 11.5 years; and that the girl whose menarche came later than the average, had her acceleration of stature at 12.5 years. In all three curves the spurt arose almost exactly a year and a half before the age of menarche.

Sitting heights. (Fig. 3.) For this physical trait, and for all subsequent traits, the diagrams will show, beside the heavy curve to represent the normals, individual material on those individuals followed over years. Most of them are demonstrative without further discussion.

Chest circumference. (Fig. 4.) (a) From birth to 5.0 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, and from Boynton. (b) From 5.2 years on, the curve is fitted to rates calculated from the data of Gray and Ayres; rates calculated from the data of Boynton tend to run lower. (c) The dotted line shows the rates calculated from Stuart, which again show no dip and subsequent rise.

Transverse chest diameter. (Fig. 4.) (a) From birth to 8.3 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, and from Boynton. (b) We are unable to weld the curves even approximately between ages 6 and 8 years. From 6.0 years is shown a curve fitted to rates calculated from the data of Gray and Ayres; while rates calculated from the data of Schwartz, which agree fairly well, are not reproduced. (c) The dotted line again shows rates calculated from data of Stuart.

Antero-posterior depth of chest. (Fig. 4.) (a) From birth to 2.8 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, and from Boynton. (b) From 4.2 years on, the

curve is fitted to rates calculated from the data of Gray and Ayres. Here the rates calculated from the data of Boynton differ so much that they are smoothed and represented by a dash line. (c) The dotted line represents Stuart.

Menarche. "The age of maximum rate of growth precedes the date of first menstruation by just one year", according to Boas. We can test this on the subject J.G., whose menarche occurred at 12.0 years, and who showed maximum rates for the several traits, read from the large original drawings, as follows: Weight at 11.5 years, stature at 11.5, sitting-height at 11.0, chest circumference at 14.0, transverse chest diameter at 12.7, antero-posterior diameter at 12.6, bi-acromial at 11.0, bi-cristal at 9.5, head-length at 11.0, breadth at 9.5, head-height no peak, face-length, face-breadth, nose-height, nose-breadth at 11.0. (Figs. 5 and 6.)

Age of maximum rate. Boas further states: "The growth curve is intimately related to the moment of maximum rate of growth, less so to the date of first menstruation." This relationship can be followed on the various diagrams, and discussion will therefore be omitted.

BOYS

Weight. Fig. 7 is reproduced in larger size, in order to demonstrate clearly its striking features:

(a) the juvenile peak in rate, showing even in the norm line,

(b) two juvenile spurts, at 4.5 and 8.5 years, in A.M.G.,

(c) two pubertal spurts, at 13.5 and 18.5 years, in H.G.

Stature. Of the four brothers recorded by Wiener, number II grew unevenly and therefore his curve is omitted from Fig. 8. Of the other three brothers, number III shows for juvenile spurt only a plateau, but even a plateau occurring at this age tends to support the contention of existence of a juvenile rate-change. The position of the pubertal peak for these three boys, figured in the order of tallness, namely, IV, III, I, is not as regular as hoped for, but the rule holds to the extent that the tallest boy had his adolescent peak at the earliest age.

Guttmann's four sons all manifest the juvenile peak. Arranged in order of final tallness, the sequence is Robert, Walter, Franz, Josef, while in order of date of spurt the order is not so neatly parallel as in

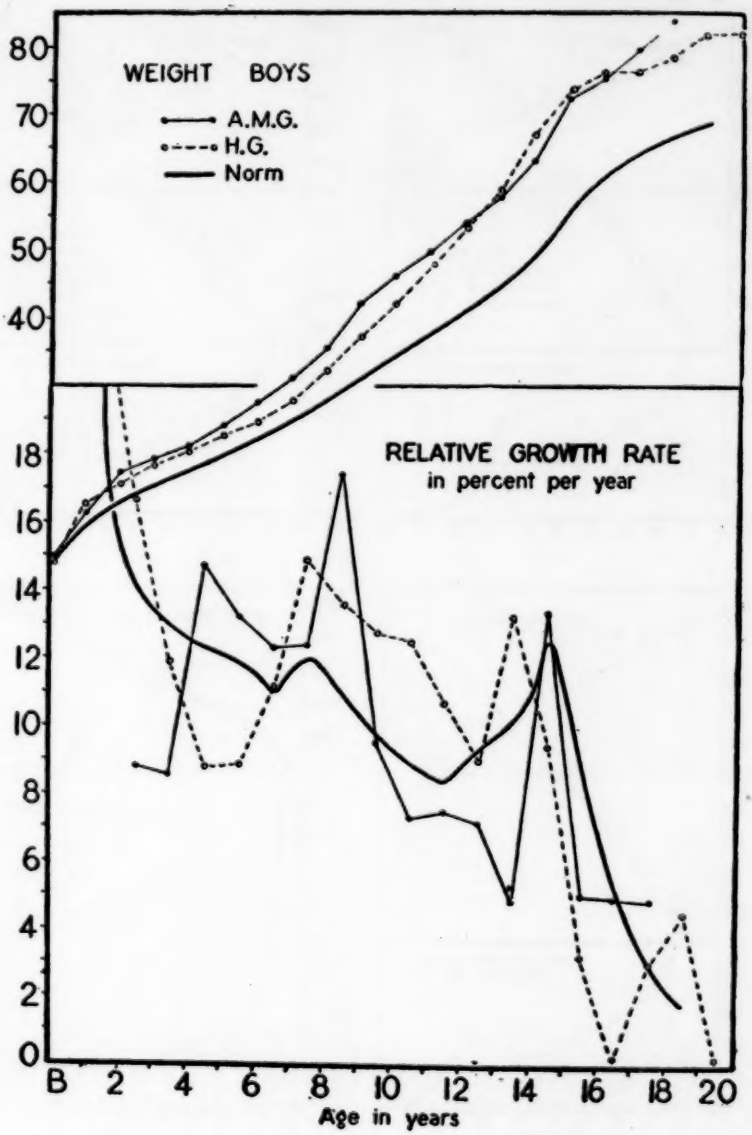
WEIGHT BOYS
A.M.G.
H.G.
Norm
80
70
60
50
40
RELATIVE GROWTH RATE
in percent per year
18
16
14
12
10
8
6
4
2
0
B
2
4
6
8
10
12
14
16
18
20
Age in years

FIG. 7

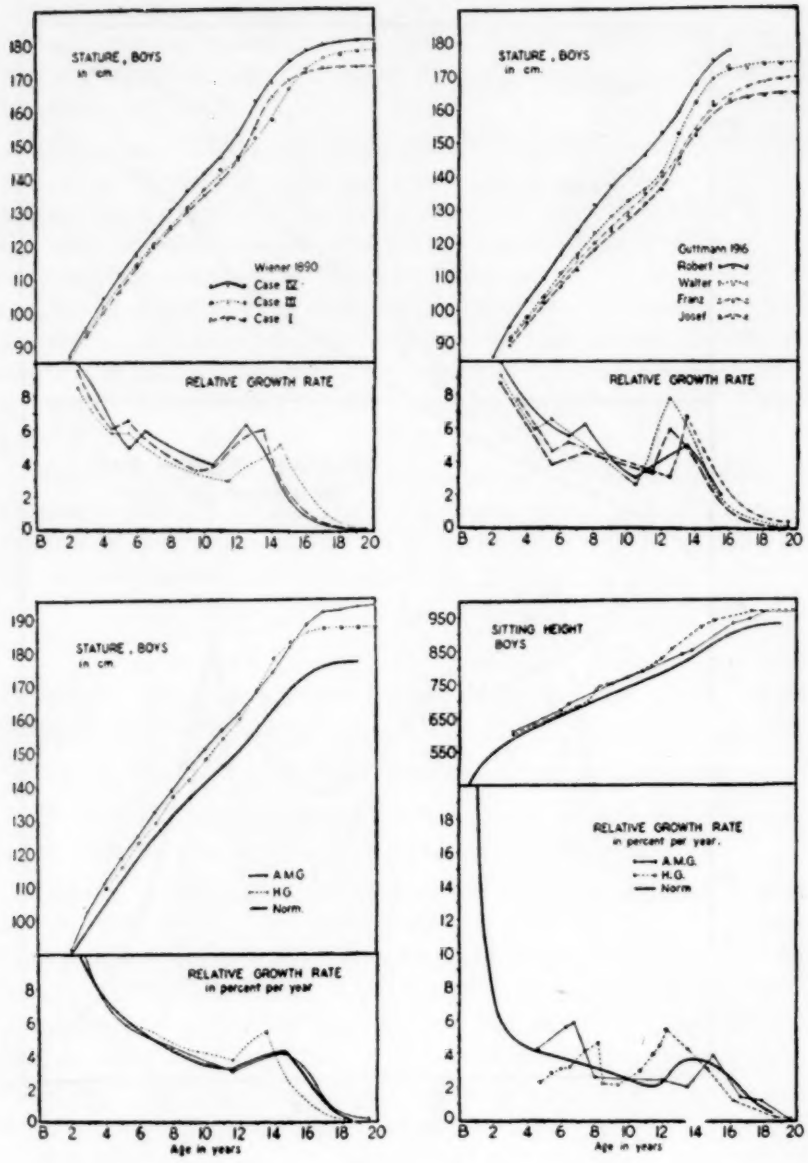
STATURE, BOYS
in cm.
Wiener 1890
Case II
Case III
Case I
RELATIVE GROWTH RATE
STATURE, BOYS
in cm.
Guttmann 1916
Robert
Walter
Franz
Josef
RELATIVE GROWTH RATE
STATURE, BOYS
in cm.
A.M.G.
H.G.
Norm.
RELATIVE GROWTH RATE
in percent per year
Age in years
SITTING HEIGHT
BOYS
RELATIVE GROWTH RATE
in percent per year.
A.M.G.
H.G.
Norm
Age in years

FIG. 8

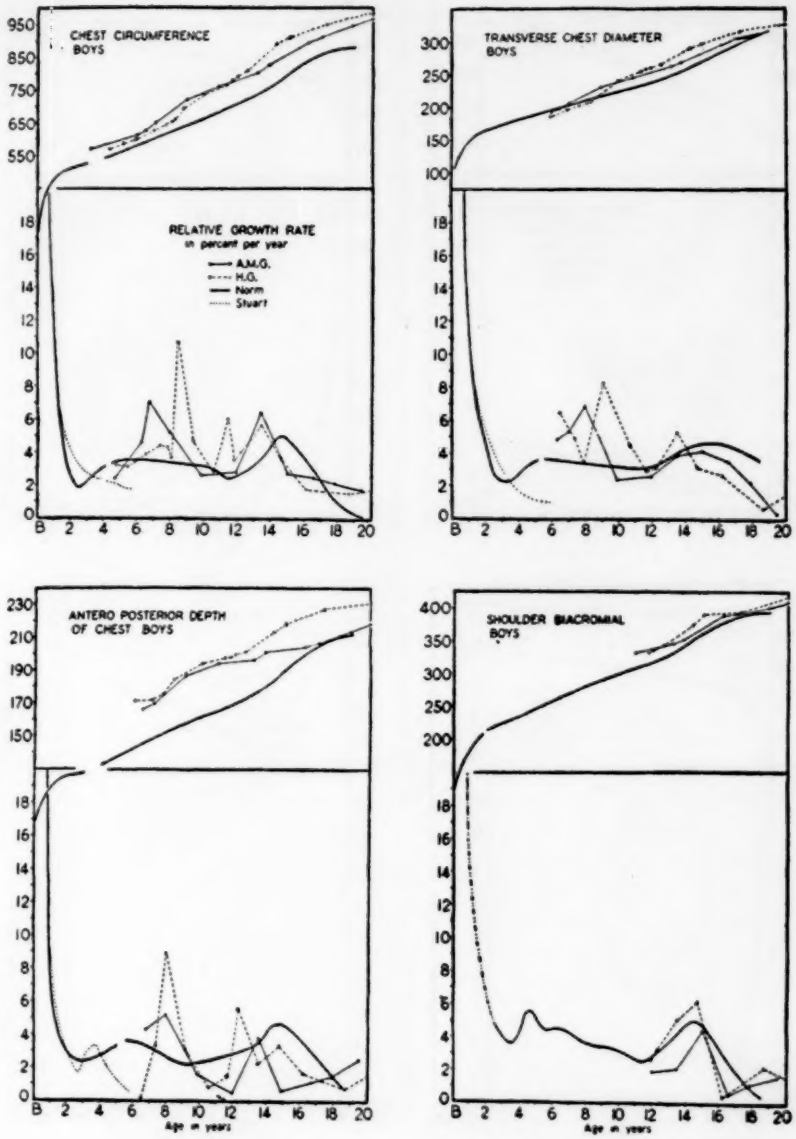
CHEST CIRCUMFERENCE
BOYS
RELATIVE GROWTH RATE
in percent per year
A.M.G.
H.G.
Norm
Stuart
TRANSVERSE CHEST DIAMETER
BOYS
ANTERO POSTERIOR DEPTH
OF CHEST BOYS
SHOULDER BIACROMIAL
BOYS
Age in years
Age in years

FIG. 9

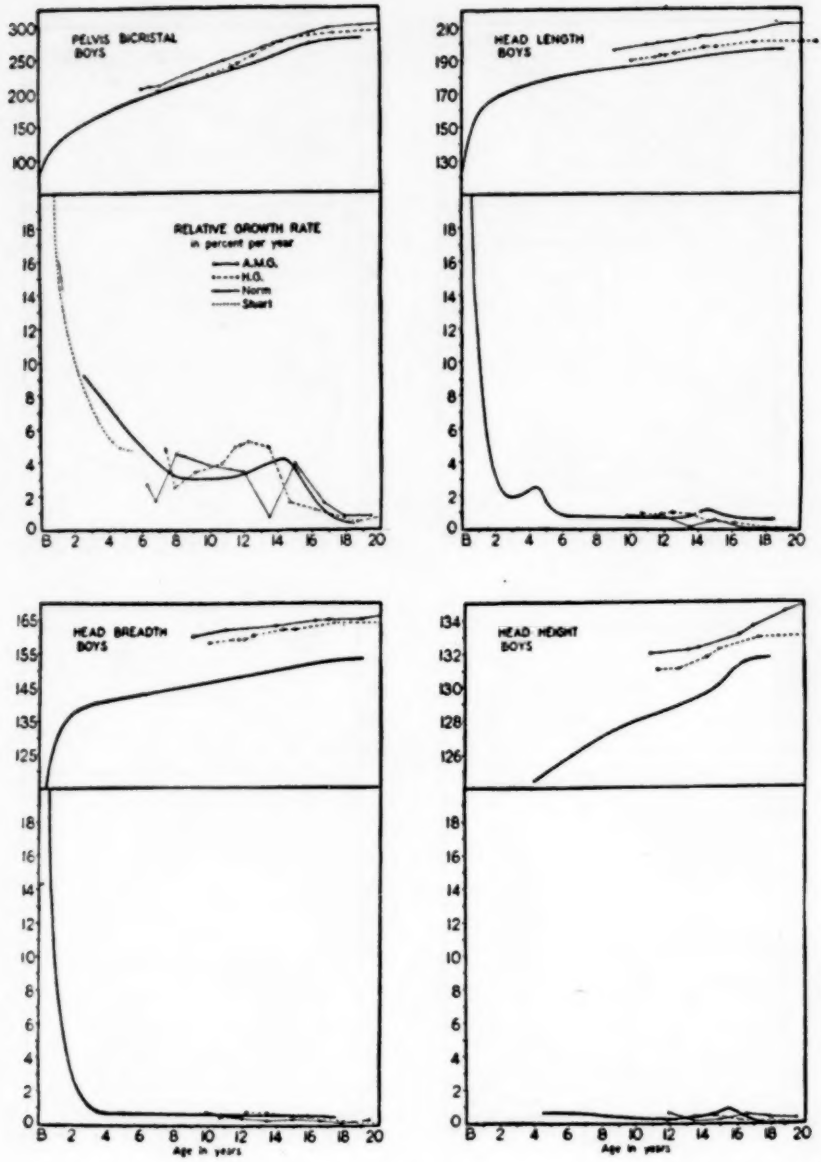
PELVIS BICRISTAL
BOYS
RELATIVE GROWTH RATE
in percent per year
A.M.G.
H.G.
Norm
Stuart
HEAD LENGTH
BOYS
HEAD BREADTH
BOYS
HEAD HEIGHT
BOYS
Age in years
Age in years

FIG. 10

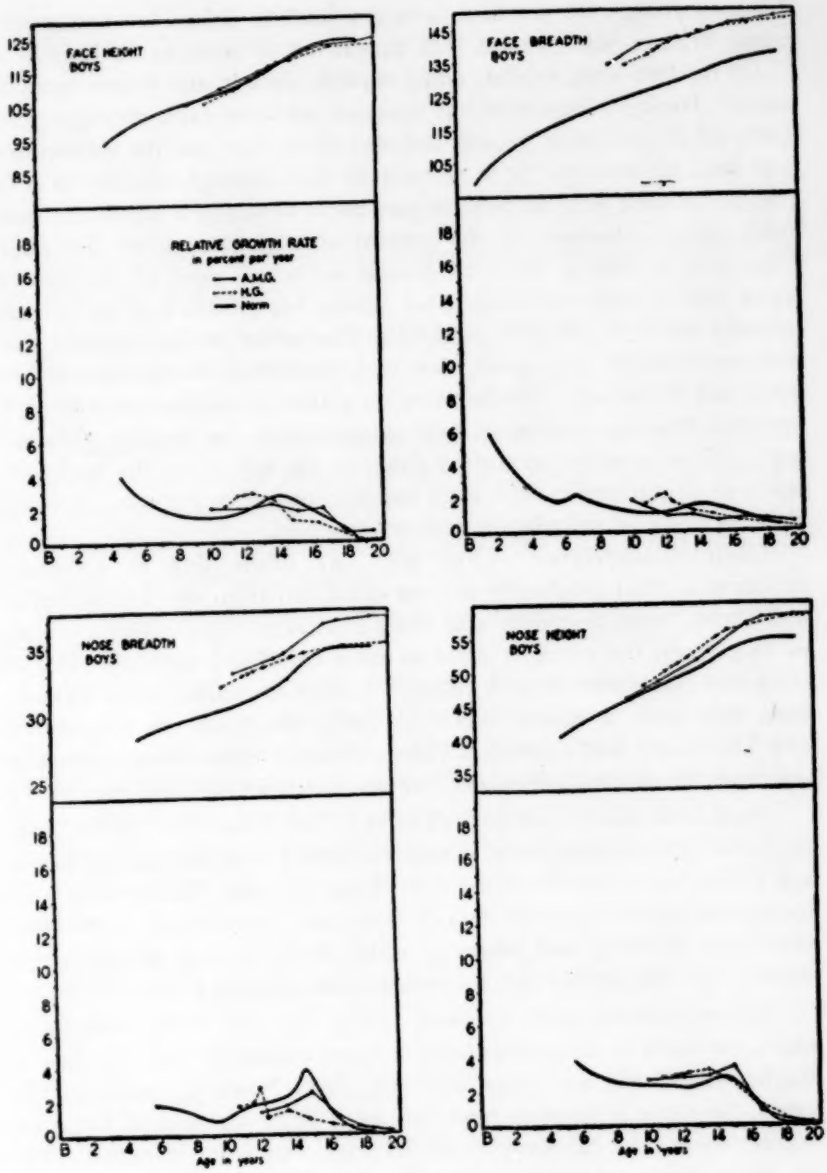
FACE HEIGHT
BOYS
FACE BREADTH
BOYS
RELATIVE GROWTH RATE
in percent per year
A.M.G.
H.G.
Norm
NOSE BREADTH
BOYS
NOSE HEIGHT
BOYS
Age in years
Age in years

FIG. 11

Wiener's group; the sequence is rather hard to define, but is approximately Walter, Josef, Franz, with Robert out of order as the latest.

Of my two boys, neither, oddly enough, showed any 6-year spurt in height. During adolescence, the younger, who was taller through practically all the period of growth and also at the end, had the acceleration later than his brother. It is noteworthy that although this boy is 6 ft. 4 in. tall in bare feet, his relative rate curve throughout shows the most extraordinary closeness to the general average rate curves for boys. From this, as well as from his general secondary signs of maturity, it seems fair to judge that despite his tallness his growth may be rated as normal; and it is plausible to predict that when similar seriatim data becomes available on a giant, that such parallelism to the normal rate curve will be lacking. Furthermore, in giants or retarded growers, it is expected that the rate-curve, now demonstrated for healthy girls and boys, will as a whole be shifted either to the left along the horizontal age-scale in conformity with early maturation and/or oversize, or to the right in cases of retardation and/or dwarfism.

Chest circumference. (Fig. 9.) (a) From birth to 4.2 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, from Meredith, and from Schwartz. (b) From 4.5 years to 19.5 years, the curve is fitted to rates calculated from the data of Gray and Ayres; while rates calculated from Meredith, from Weissenberg, and from Schwartz which lie fairly close, are not reproduced. (c) The dotted line represents rates calculated from Stuart, which do not show the dip and subsequent rise we find from the other data.

Transverse chest diameter. (Fig. 9.) (a) From birth to 5.2 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, and from Meredith. (b) From 5.5 years, the curve is fitted to rates calculated from the data of Gray and Ayres; while rates calculated from Meredith and Schwartz, which lie fairly close, are not reproduced. (c) The dotted line represents rates calculated from Stuart.

Antero-posterior depth of chest. (Fig. 9.) (a) From birth to 5.0 years, the curve is fitted graphically to rates calculated from the data of Bayley and Davis, and from Meredith. (b) From 5.5 years to 18.5 years, the curve is fitted to rates calculated from the data of Gray and Ayres; while rates calculated from Schwartz and from Meredith, which lie fairly close, are not reproduced. (c) The dotted line represents rates calculated from Stuart, which for this trait confirm the infantile drop and subsequent rise of rate with which we are especially concerned.

SUMMARY

What this paper has to contribute that is different from most articles on growth consists in the following:

1. Long-range records on three normal children; birth to maturity so far as was possible.

2. Large number of traits: 15.

3. Instantaneous rates as a useful method of interpreting growth.

4. Demonstration of a spurt of growth in early childhood, roughly at 6 years, for many of the traits.

5. Standards for growth-rates at successive ages, for normal girls and boys, in Appendices A and B.

6. Original absolute measurements on the three children, in Appendices C, D, E.

7. It may be added that the bone-age was determined by x-rays as follows: In J.G. at 10 years, with films that looked age 12; and at 12½ years with results again looking 2 years older. In H.G. at 15 years, 4 months and at 17 years, 4 months, with results at each time conforming to calendar age. In A.M.G., at 16 years and looked age 16.

8. I wish to acknowledge the help of Miss Sylvia Lowe in making the many calculations, and of Dr. Francis E. Howard in drawing the diagrams.

APPENDIX A

Instantaneous growth rates for girls
From birth to maturity.

	W	S	Si	C	T	AP	BA	BC	L	B	OH	MN	BZ	NH	NB
Birth	298	105	...	...	...	...	...	...	...	...	..	..	..	..	..
0.1	224	76	74	80	70	35	71	112	55	64	..	..	..	..	..
0.2	167	60	60	58	65	30	62	82	43	47	..	..	..	..	..
0.3	129	48	48	44	52	25	54	58	34	36	..	..	..	..	..
0.4	102	40	39	34	39	20	45	39	26	28	..	..	..	..	..
0.5	81	33	32	26	30	17	36	29	22	22	..	..	..	..	..
0.6	67	28	27	20	24	14	28	23	19	17	..	..	..	..	..
0.7	55	25	24	16	19	12	21	20	16	14	..	..	..	..	..
0.8	47	22	21	13	15	10	18	18	13	11	..	..	..	..	..
0.9	41	21	19	11	13	8	15	17	11	9	..	..	..	..	..
1.0	37	20.0	17.7	9.0	10.7	7.1	13.5	15.7	10.0	7.1	..	..	..	..	..
1.5	22	14.8	14.1	5.2	6.3	2.8	10.3	13.1	4.3	3.3	..	..	..	..	..
2.	18.7	12.0	11.2	3.5	5.7	1.9	8.1	10.5	2.9	2.3	..	..	5.7	..	..
3.	15.2	9.0	6.5	2.4	3.8	0.9	4.8	7.3	2.0	1.5	..	..	3.4	..	..
4.	13.3	7.2	4.9	2.9	2.8	0.7	4.2	5.6	2.5	1.1	..	..	1.9	..	..
5.	12.7	6.2	4.6	3.4	2.4	0.9	3.8	4.4	1.9	0.9	..	..	2.5	..	..
6.	12.7	5.5	4.3	3.6	2.8	1.4	4.0	3.7	1.0	0.7	..	1.7	1.7	2.2	1.1
7.	12.0	4.8	3.8	3.6	2.9	2.0	4.3	5.1	0.8	0.6	0.6	1.2	1.6	1.8	1.0
8.	11.6	4.3	3.2	3.6	3.1	2.9	3.2	4.7	0.7	0.6	0.6	1.3	1.7	1.8	1.0
9.	11.1	3.9	2.4	3.7	3.5	3.5	3.0	3.4	0.6	0.6	0.6	1.5	1.6	2.0	1.2
10.	11.2	4.0	2.6	3.8	3.8	3.0	3.6	3.8	0.6	0.5	0.6	1.7	1.4	2.2	1.5
11.	12.0	4.7	3.3	4.3	4.0	2.7	3.9	4.3	0.5	0.5	0.6	2.0	1.2	1.2	2.2
12.	11.6	4.2	3.4	4.5	3.8	3.3	3.4	4.7	0.5	0.5	0.6	1.9	1.1	2.1	2.1
13.	9.0	2.6	3.2	3.9	3.2	3.2	2.6	4.3	0.4	0.4	0.5	1.7	1.0	1.6	1.0
13.5	7.7	2.1	2.9	3.1	2.9	2.7	2.1	3.7	0.4	0.4	0.4	1.5	0.9	1.4	0.7
14.	6.3	1.6	2.4	2.3	2.4	2.2	1.7	3.0	0.5	0.4	0.2	1.4	0.9	1.3	0.6
14.5	4.9	1.1	2.0	1.6	1.9	1.7	1.3	2.4	0.6	0.4	0.2	1.2	0.8	1.2	0.5
15.	3.6	0.9	1.5	1.1	1.5	1.4	1.0	1.9	0.4	0.3	0.2	1.1	0.8	1.0	0.4
15.5	2.4	0.4	0.9	0.7	1.1	1.0	0.8	1.5	0.3	0.3	0.2	1.0	0.7	0.8	0.3
16.	1.7	0.2	0.6	0.5	0.7	0.8	0.7	1.2	0.3	0.3	0.2	0.8	0.6	0.5	0.3
16.5	1.2	0.1	0.3	0.3	0.5	0.6	0.7	0.9	0.4	0.3	0.2	0.7	0.4	0.2	0.3
17.	0.9	...	0.2	0.2	0.2	0.4	0.6	0.8	0.6	0.2	0.2	0.4	0.3	0.1	0.3
17.5	0.6	...	0.1	0.1	0.1	0.3	0.6	0.6	0.6	0.2	0.1	0.1	0.2	..	0.3
18.	0.3	...	0.1	...	0.1	0.2	...	0.5	0.6	...	..	..	0.1	..	0.3
18.5	0.1	...	0.1	...	...	...	...	0.4	...	...	..	..	..	..	..

APPENDIX B

Instantaneous growth for boys
From birth to maturity.

	W	S	Si	C	T	AP	BA	BC	L	B	OH	MN	BZ	NH	NB
Birth	303	105	...	...	...	...	...	...	...	...	..	..	..	..	..
0.1	243	78	76	72	68	41	41	41	57	80	..	..	..	..	..
0.2	183	60	59	54	63	34	80	67	41	51	..	..	..	..	..
0.3	134	47	43	43	51	26	61	50	31	35	..	..	..	..	..
0.4	103	38	35	35	40	20	45	39	25	28	..	..	..	..	..
0.5	81	31	29	29	31	17	36	31	21	22	..	..	..	..	..
0.6	66	26	25	24	25	14	29	25	18	18	..	..	..	..	..
0.7	55	23	21	20	20	12	24	21	16	15	..	..	..	..	..
0.8	46	22	18	17	17	10	20	18	14	12	..	..	..	..	..
0.9	40	21	16	15	14	9	17	17	12	11	..	..	..	..	..
1.0	36	20.0	14.5	12.0	11.8	7.6	14.5	15.8	10.4	9.0	..	..	..	..	..
1.5	20	13.4	9.5	5.3	6.8	4.0	9.5	12.2	5.6	5.1	..	..	..	..	..
2.0	16.2	11.0	7.6	2.7	4.6	3.0	6.6	10.2	3.1	2.9	..	..	5.0	..	..
3.0	13.6	8.9	5.1	2.2	2.3	2.4	4.0	8.6	1.9	1.0	..	..	3.6	..	..
4.0	12.3	7.4	4.4	3.0	2.7	2.7	4.2	7.4	2.3	0.7	..	..	2.5	..	..
5.0	11.4	6.4	4.0	3.5	3.5	2.3	5.2	6.1	1.6	0.6	0.6	3.3	1.9	..	..
6.0	10.8	5.5	3.7	3.6	3.6	3.6	4.5	4.9	0.8	0.6	0.6	2.5	1.9	3.5	1.8
7.0	11.7	4.8	3.4	3.5	3.5	3.2	4.3	3.9	0.7	0.6	0.5	1.9	2.0	2.9	1.6
8.0	11.9	4.3	3.1	3.4	3.4	2.7	3.6	3.2	0.7	0.6	0.4	1.6	1.6	2.6	1.2
9.0	10.8	3.6	2.8	3.3	3.3	2.3	3.4	3.0	0.7	0.6	0.4	1.4	1.3	2.5	0.8
10.0	9.7	3.4	2.4	3.2	3.2	2.4	3.2	3.0	0.6	0.6	0.3	1.4	1.1	2.4	1.0
11.0	8.7	3.2	2.1	2.7	3.1	2.6	2.7	3.1	0.6	0.6	0.2	1.5	1.0	2.3	1.5
12.0	9.0	3.4	2.3	2.6	3.2	2.8	2.9	3.3	0.6	0.6	0.2	1.8	1.1	2.2	1.8
13.0	10.6	3.8	3.4	3.2	3.7	3.2	3.8	3.7	0.7	0.6	0.3	2.4	1.4	2.4	2.0
13.5	11.4	4.0	3.6	3.7	4.0	3.5	4.3	3.9	0.8	0.6	0.3	2.6	1.5	2.6	2.3
14.0	12.2	4.1	3.7	4.3	4.3	4.1	4.8	4.1	1.0	0.6	0.4	2.7	1.6	2.8	2.8
14.5	12.7	4.2	3.6	4.9	4.5	4.6	5.0	4.2	1.2	0.6	0.5	2.6	1.5	2.9	3.8
15.0	11.1	3.8	3.3	4.8	4.6	4.7	4.7	3.6	1.0	0.6	0.7	2.3	1.4	2.6	3.2
15.5	9.0	3.1	3.0	4.3	4.6	4.3	4.1	2.7	0.9	0.6	0.8	2.0	1.3	2.1	2.2
16.0	7.2	2.4	2.6	3.7	4.6	3.8	3.3	2.0	0.7	0.5	0.6	1.7	1.2	1.7	1.3
16.5	5.4	1.7	2.1	3.1	4.5	3.3	2.5	1.3	0.7	0.5	0.4	1.5	1.0	1.2	0.8
17.0	4.0	1.1	2.5	2.4	4.3	2.6	1.9	0.9	0.6	0.5	0.2	1.2	0.8	0.6	0.4
17.5	2.9	0.6	1.1	1.5	4.1	2.1	1.3	0.6	0.6	0.4	0.1	0.9	0.6	0.2	0.1
18.0	2.2	0.3	0.7	1.0	3.8	1.5	0.8	0.4	0.6	..	..	0.6	0.5	0.1	0.1
18.5	1.6	0.1	0.6	0.6	3.5	0.9	0.4	0.3	..	..	..	0.2	0.3	0.1	..

APPENDIX C

Individual growth record of a normal girl J. G.
From birth to maturity.

	W	S	Si	C	T	AP	BA	BC	L	B	OH	MN	BZ	NH	NB
Birth	4.08	530	...	...	...	...	...	...	...	...	...	...	...	...	...
1.000	11.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2.000	13.7	880	528	495	165	131	...	150	...	...	...	...	...	...	...
2.428	15.0	922	538	500	170	135	...	155	...	...	...	...	...	...	...
3.000	15.0	970	569	510	175	137	...	160	...	...	...	...	...	...	...
4.562	19.5	1082	...	...	...	...	...	...	170	141	...	90	117	36	28
4.655	19.9	1087	...	...	...	...	...	...	175	141	...	90	...	35	...
5.033	20.6	1137	620	550	190	142	251	185	175	143	120	94	118	40	28
5.491	21.3	1164	642	560	191	143	255	190	178	144	120	95	119	42	28
6.000	23.6	1208	663	572	199	144	266	194	180	144	120	96	122	43	29
6.351	24.5	1235	681	575	205	149	265	197	181	145	120	98	122	43	30
7.151	27.2	1302	710	582	205	149	279	204	182	146	120	103	124	45	31
7.981	29.0	1333	...	...	...	...	...	...	...	...	...	...	...	...	...
9.066	31.3	1413	746	642	209	152	301	220	183	148	120	106	128	47	31
10.017	33.6	1462	760	668	216	156	311	233	184	150	120	108	128	48	31
11.000	39.0	1537	...	...	...	...	...	...	...	...	...	...	...	...	...
12.193	46.3	1598	832	672	237	162	344	263	187	152	120	114	132	51	32
13.170	49.4	1636	858	690	256	171	348	272	188	153	120	114	133	52	32
14.041	56.1	1643	...	...	...	...	...	...	...	...	...	...	...	...	...
14.773	59.0	1668	870	830	264	183	354	289	188	153	120	114	134	52	32
16.033	59.0	1671	876	830	264	184	354	290	189	154	120	114	135	52	32
17.033	59.0	1674	881	854	264	187	357	296	190	154	120	115	135	52	32

APPENDIX D

Individual growth record of a normal boy A. M. G.
From birth to maturity.

	W	S	Si	C	T	AP	BA	BC	L	B	OH	MN	BZ	NH	NB
Birth	4.20	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1.000	11.2	760	...	...	...	...	...	...	...	...	...	...	...	...	...
2.000	17.2	910	...	...	...	...	...	...	...	...	...	...	...	...	...
3.167	19.5	1040	600	570	...	...	...	...	...	...	...	...	...	...	...
4.000	20.8	1110	...	...	...	...	...	...	...	...	...	...	...	...	...
5.000	24.0	1185	...	...	...	...	...	...	...	...	...	...	...	...	...
6.000	27.3	1255	673	610	200	157	...	205	...	...	...	...	...	...	...
6.528	30.5	1285	693	625	200	166	...	208	...	...	...	...	...	...	...
7.082	30.6	1330	716	650	200	171	...	210	...	...	...	...	...	...	...
8.000	35.1	1388	...	...	...	...	...	...	...	...	...	...	...	...	...
9.000	41.1	1452	753	720	245	196	...	229	196	160	132	105	134	44	33
10.000	46.0	1507	...	...	...	...	...	...	...	...	...	...	...	...	...
10.893	49.4	1556	790	756	249	204	332	246	199	162	132	110	140	50	33
12.000	52.2	1612	...	...	...	...	...	...	...	...	...	...	...	...	...
13.164	59.4	1674	838	800	261	192	347	265	202	163	132	113	142	51	34
13.832	59.4	1715	841	844	268	204	352	266	203	163	132	116	142	53	34
15.000	70.8	1808	...	...	...	...	...	...	...	...	...	...	...	...	...
16.156	75.7	1885	927	896	295	204	391	291	206	165	133	120	146	58	37
17.003	78.0	1913	938	903	304	204	393	295	207	165	134	123	146	58	37
18.885	83.5	1928	960	950	317	212	402	298	211	165	134	123	148	58	37
20.131	88.4	1931	960	970	318	219	410	301	211	166	135	124	149	58	37

APPENDIX E

Individual growth record of a normal boy H. G.
From birth to maturity.

	W	S	Si	C	T	AP	BA	BC	L	B	OH	MN	BZ	NH	NB
Birth	3.89	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1.000	12.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2.000	15.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3.000	18.2	1060	...	...	...	...	...	...	...	...	...	...	...	...	...
4.351	20.9	1105	630	570	...	...	...	...	...	...	...	...	...	...	...
5.258	22.7	1157	643	577	...	...	...	...	...	...	...	...	...	...	...
5.751	23.1	1210	648	580	...	...	...	...	...	...	...	...	...	...	...
6.049	24.0	1230	673	590	180	171	...	...	...	...	...	...	...	...	...
7.000	27.7	1290	678	630	205	171	...	200	...	...	...	...	...	...	...
7.712	30.9	1340	698	630	200	175	...	210	...	...	...	...	...	...	...
8.071	32.0	1375	734	655	200	184	...	...	...	...	...	...	...	...	...
8.277	32.0	1385	741	660	200	184	...	210	...	...	...	...	...	...	...
8.759	35.4	1420	749	695	...	...	...	...	...	...	...	...	...	...	...
10.008	41.5	1482	769	745	246	202	...	227	189	158	131	105	134	48	32
11.353	48.6	1575	801	765	258	190	332	237	191	159	131	108	137	50	33
11.696	49.0	1581	816	781	252	191	333	242	192	159	131	109	138	49	31
12.022	53.1	1597	820	810	264	194	334	250	192	159	131	110	139	52	33
12.644	58.1	1648	852	810	257	195	343	253	193	160	131	112	141	52	32
14.348	71.2	1800	916	900	294	210	374	275	197	162	132	118	144	55	34
15.019	71.2	1825	935	914	296	222	390	278	197	162	132	118	144	56	34
16.000	75.4	1854	...	...	...	...	...	...	...	...	...	...	...	...	...
17.340	78.5	1862	962	950	318	227	394	286	200	164	133	122	146	58	35
18.000	77.6	1867	...	...	...	...	...	...	...	...	...	...	...	...	...
20.069	82.1	1868	967	990	320	232	418	289	200	164	133	122	148	58	35
20.945	82.6	1870	968	1006	325	236	423	292	200	164	133	122	148	58	36

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THE SEASONAL OCCURRENCE OF TULAREMIA IN THE NORTH CENTRAL STATES*

BY BANNER BILL MORGAN**

INTRODUCTION

TULAREMIA is a highly infectious disease, primarily in wild rodents and secondarily in man. The causative agent is classified as *Pasteurella tularensis*. The disease was first reported by McCoy (1911, from California ground squirrels (*Citellus beecheyi*). Since then numerous cases have been reported in the United States. It is rapidly becoming an important disease with a human mortality rate of approximately 5 per cent. To medical men, tularemia is the first American disease. Forty-six states, District of Columbia, and several foreign countries, namely; Japan (1925), Russia (1928), Norway (1929), Canada (1930), Sweden (1931), Austria (1935), and more recently French West Africa (1940), have reported tularemia.

There is some discussion as to the systematic position of the tularemia organism. Bergey (1939) listed the organism under the name *Pasteurella tularensis*, as one of the plague-like group, being distantly related to the bubonic plague organism, *P. pestis*. The tularemia organism differs from *P. pestis* in its cultural characteristics, growth requirements (needing cystine), and its antigen reaction. It is related to the *Brucellus* group antigenically as it cross agglutinates with *B. abortus* (undulant fever). Microscopically, tularemia is a small gram negative, non-motile, aerobic rod or bacillus, which has bacillary and coccoid tendencies. Green (1939) believes tularemia may be in the nature of a virus. Many writers are content to call the organism *Bacterium tularense*. As the question is not definitely settled, it appears

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best to leave the organism classified as *P. tularensis* as listed in Bergey's Manual (1939) until enough evidence is gathered to do otherwise.

Tularemia is transmitted among wild animals by blood sucking arthropods. Some of the vectors in the United States include the deer fly (*Chrysops* sp.), wood ticks (*Dermacentor andersoni* and *D. variabilis*), rabbit tick (*Haemaphysalis leporispalustris*), rabbit fleas (*Cediopsylla simplex* and *Hoplopsyllus affinis*), dog flea (*Ctenocephalides canis*), and possibly the rabbit louse (*Haemodipsus ventricosus*). *Dermacentor andersoni* and *D. variabilis* are known to bite man. One of the rabbit fleas (*H. affinis*) and the dog flea (*C. canis*) is also capable of biting man. The other mentioned arthropod vectors are not known to attack man, with the exception of the deer fly (*Chrysops* sp.). Tularemia has been isolated from the bedbug (*Cimex* sp.) but so far it has not been known to transmit the disease to humans.

Francis (1937) stated that cottontail rabbits, jackrabbits, and snow shoe hares are the direct cause of over 90 per cent of human cases of tularemia in the United States. In most cases the disease is contracted by dressing rabbit carcasses. Tularemia can enter through unbroken skin, by a cut, scratch, or puncture wound. Since a large number of laboratory workers have contracted the disease despite extra precautions, there is some reason to believe that tularemia may be air borne. Another potential danger of tularemia has been shown by the isolation of *P. tularensis* from the water of certain Montana streams. The disease may have been spread by some aquatic animal.

Approximately one per cent of the wild rabbits are infected in nature unless an epizootic occurs. This is true of cottontail rabbits (*Sylvilagus floridanus mearnsi*) in the University of Wisconsin Arboretum, as over 100 cottontail rabbits were examined with only one rabbit infected with tularemia. This rabbit, however, was the direct cause of two human cases of tularemia. In Iowa, over 200 cottontail rabbits were examined before tularemia was encountered. Waller (1940) pointed out that the per cent may be higher in areas where wild rabbits are concentrated.

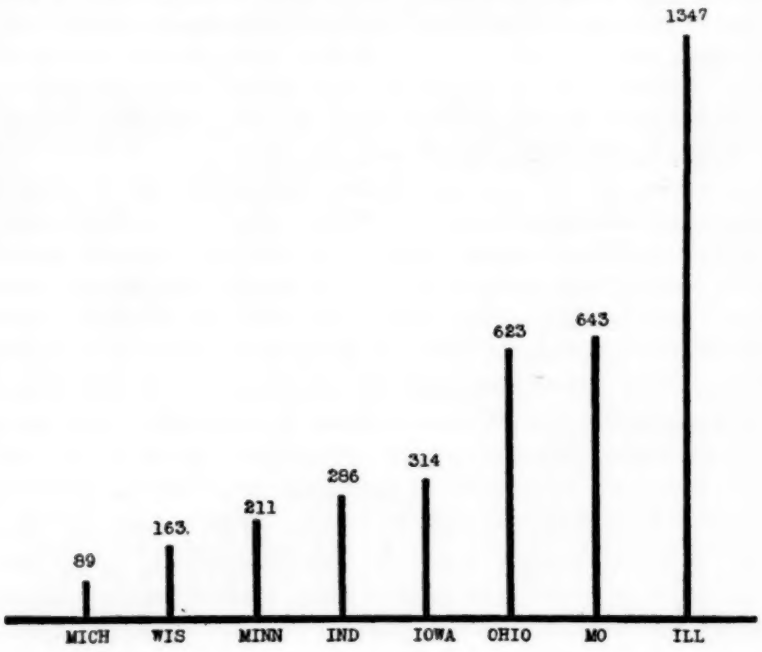
The remaining 10 per cent of the human cases may be caused by the bite of the infected deer fly, wood ticks, possibly fleas, and direct contact with wild animals and birds other than rabbits. Many cases are on record by contact with infected sheep, squirrel, sage hen, coyote, deer, red fox, quail, horned owl, ground hog, muskrat, skunk, beaver,

and one case from a bull snake. Other causes include humans being bitten by the cat, skunk, coyote, squirrel, opossum, dog, hog, lamb, and white rat. In these cases, contamination of the mouth of the animals involved by eating infected animals is mainly responsible. One case is on record of a person contracting tularemia from a scratch by a cat.

The following animals have been found in nature to be infected with tularemia: ground squirrel, cottontail rabbit, jackrabbit, snow shoe hare, rat, mouse, quail, grouse, sheep, sage hen, muskrat, beaver, horned owl, grey fox, and dog. The following group of animals have been infected experimentally with varying degrees of susceptibility: snow shoe hare, cottontail rabbit, jackrabbit, rat, ground squirrel, mouse, guinea pig, sheep, opossum, monkey, gopher, meadow mouse, water rat, wood chuck, Virginia ground hog, prairie dog, kitten, dog,

TABLE 1

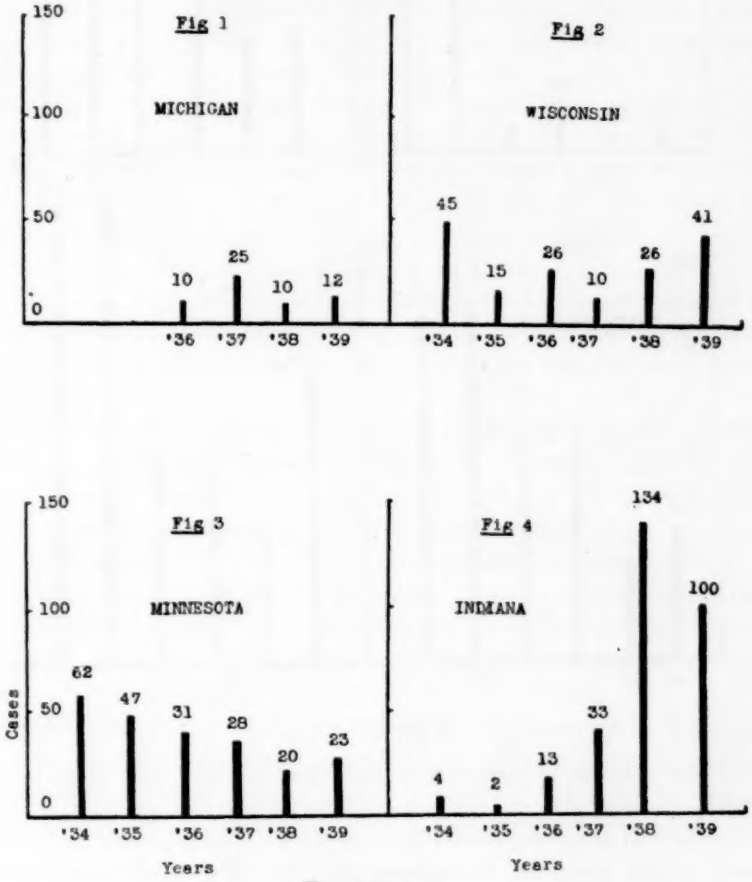
Total number of human cases of tularemia for the North Central States over a six-year period (1934-39)



silver fox, red fox, coyote, grey fox, muskrat, quail, chicken, ruffed grouse, sharp-tailed grouse, red-tailed hawk, red-shouldered hawk, pheasant, and horned owl. As a rule, rodents were the most susceptible while carnivores and birds were the least.

The tables presented in this paper may be affected by an unmeasurable human factor. This factor pertains to the medical skill and ability of physicians to diagnose tularemia. Until 1935 relatively few cases of

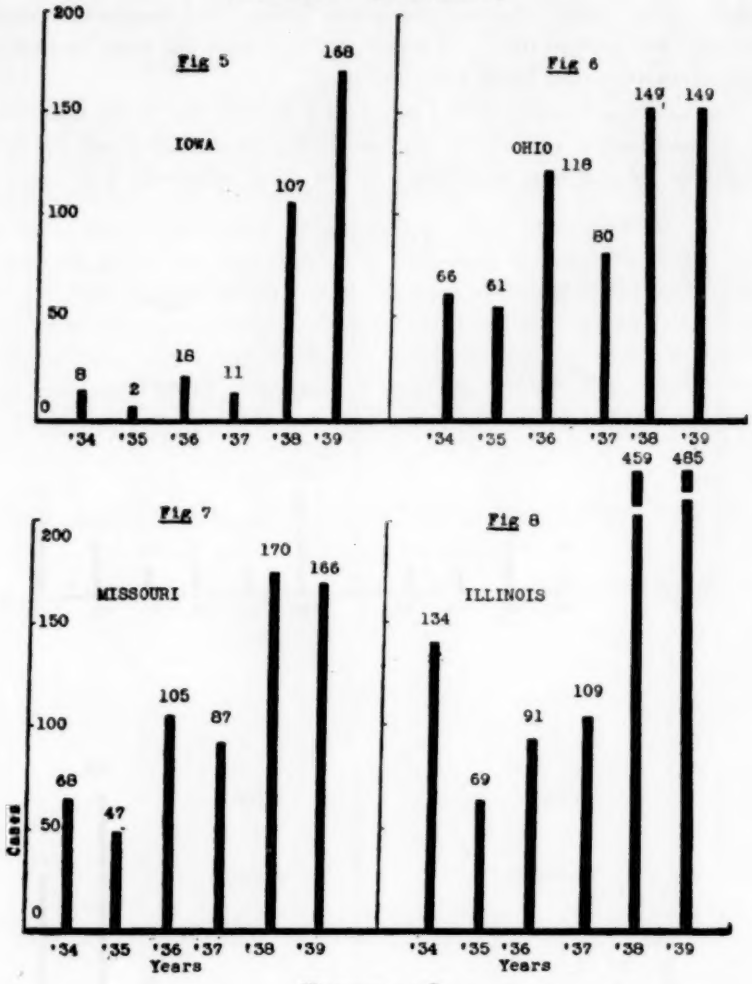
TABLE 2



FIGURES 1-4

Total number of human cases of tularemia per year 1934-39

TABLE 2 (*Continued*)



FIGURES 5-8

Total number of human cases of tularemia per year 1934-39

tularemia had been reported. In recent years people have been more aware of the existence of tularemia. Physicians have become more skillful in their diagnosis; where in the past, many cases of tularemia were or were not reported. There is no way of knowing what per cent error may exist in the number of cases reported.

Precaution refers to the care in handling and dressing of carcasses of potential tularemia-bearing animals. Hunters should avoid direct contact with the blood of killed animals, scratches or bites of live ones. This is particularly true in dressing animals, so the use of rubber gloves is recommended. This precaution should be carried over until the food is well cooked. Care should be exercised in the handling of sharp instruments to avoid self inoculations by cuts or puncture wounds.

The purpose of this paper is to show the seasonal occurrence of tularemia in the North Central States, namely; Wisconsin, Michigan, Ohio, Missouri, Iowa, Indiana, Illinois, and Minnesota. The seasonal occurrence of tularemia is dependent upon the habits of arthropod vectors and the game laws in the various states.

Table 1 shows the total number of human cases of tularemia by states for the years 1934-39 consecutively for a total of 3676 cases. Illinois leads with 1347 cases followed by Missouri (643 cases), Ohio (623 cases), Iowa (314 cases), Indiana (286 cases), Minnesota (211 cases), Wisconsion (163 cases), and Michigan (89 cases). This may correlate with the total population of each state.

Table 2, Figs. 1-8, show the total number of human cases of tularemia reported for each year (1934-39) in each of the North Central States. These tables merely show which years had the most number of cases reported.

In Michigan (Table 2, Fig. 1) only 4 years of data were available. In 1936, 110 cases of human tularemia were reported; 1937, 25 cases; 1938, 10 cases; and 1939, 12 cases. There is not enough evidence to show whether the disease is on the decrease or increase.

In Wisconsin (Table 2, Fig. 2) the disease fluctuated widely. The year 1934 was high with 45 human cases reported, and in the following years; 1935, 15 cases; 1936, 26 cases; 1937, 10 cases; 1938, 26 cases; and 1939, 41 cases. Again, there is not enough evidence to point out the trend of the disease in Wisconsin.

Minnesota (Table 2, Fig. 3) shows a slight decrease in the number of cases of human tularemia reported; however, this cannot be definitely stated until a longer period of time is studied. In 1934, 62 cases of human tularemia were reported; 1935, 47 cases; 1936, 31 cases; 1937, 28 cases; 1938, 20 cases; and 1939, 23 cases.

The disease varied a great deal in Indiana (Table 2, Fig. 4). No definite statement can be made on the trend of human tularemia in this

state. In 1934, 4 cases were reported; 1935, 2 cases; 1936, 13 cases; 1937, 38 cases; 1938, 134 cases; and 1939, 100 cases.

In Iowa (Table 2, Fig. 5) the disease is showing a definite increase in number of cases reported. With 8 cases in 1934 the disease has steadily increased; 1935, 2 cases; 1936, 18 cases; 1937, 11 cases; 1938, 107 cases; and 1939, 168 cases.

Reported cases of human tularemia appear to be increasing in Ohio (Table 2, Fig. 6). In 1934, 66 cases were reported; 1935, 61 cases; 1936, 118 cases; 1937, 80 cases; 1938, 149 cases; 1939, 149 cases.

Missouri (Table 2, Fig. 7) shows an increase of human cases of tularemia reported, through the 6-year period. In 1934, 68 cases were reported; 1935, 47 cases; 1936, 105 cases; 1937, 87 cases; 1938, 170 cases; and 1939, 166 cases.

In Illinois (Table 2, Fig. 8), reported cases of human tularemia appear to be increasing. In 1934, 134 cases were reported; 1935, 69 cases; 1936, 91 cases; 1937, 109 cases; 1938, 459 cases; and 1939, 485 cases.

Reported cases of human tularemia in the North Central States appear to be definitely on the increase, for which there may be several reasons. There is the possibility of an epizootic in wild rodents (mainly cottontail rabbits) which was evident during 1938 and 1939. Also, during the past few years, physicians have learned to recognize the disease, and have become more accurate in their diagnosis. Increase in population of humans and wild animals is also a factor. The rabbit (cottontail) cycle in Wisconsin has been shown graphically by McCabe. In his report, the annual Wisconsin rabbit kill has increased since 1936, at which time there was a low in the cycle.

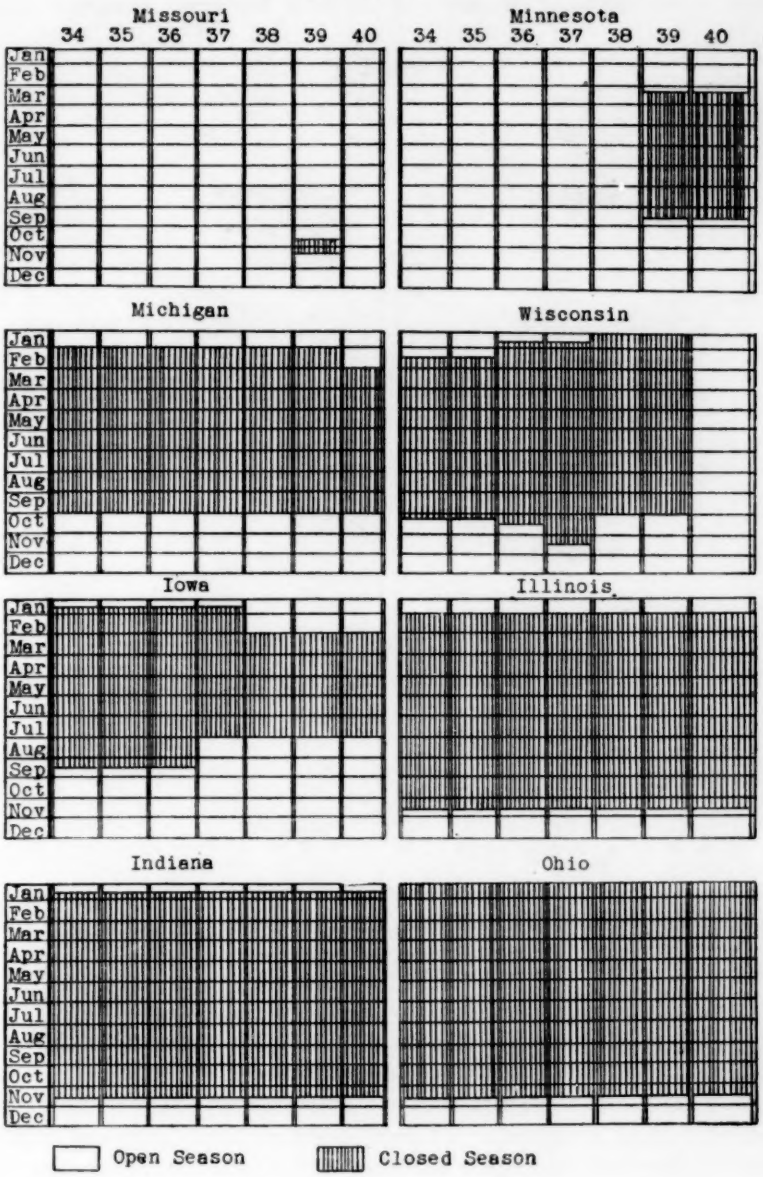
SEASONAL OCCURRENCE

Table 3 shows the hunting season of cottontail rabbits in the North Central States. Only the maximum dates or longest number of days in the open season are shown. Some states have different seasons in certain areas or sections. The table is not minutely accurate but used merely to show relationships. Table 4, Figs. 1-8, show the number of human cases of tularemia reported for each month over a 6-year period (1934-39) for the North Central States.

Table 4, Fig. 1 shows the total number of human cases of tularemia reported over a 4-year period in Michigan. Tularemia has been reported

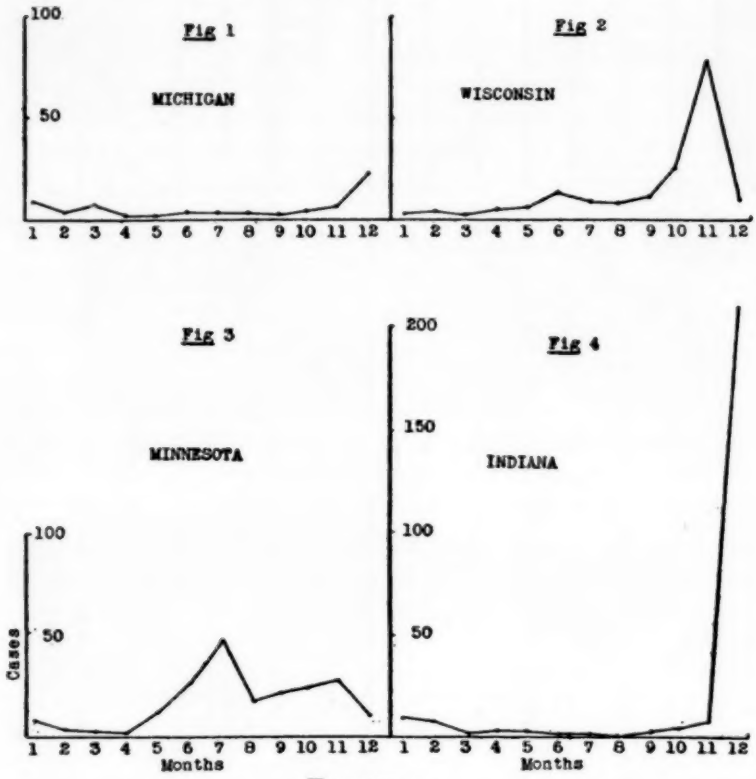
TABLE 3

Maximum hunting seasons on cottontail rabbits



in every month except September. The high months are December and January. This is in direct relationship with the cottontail hunting season which opens in October and closes in January. However, with

TABLE 4



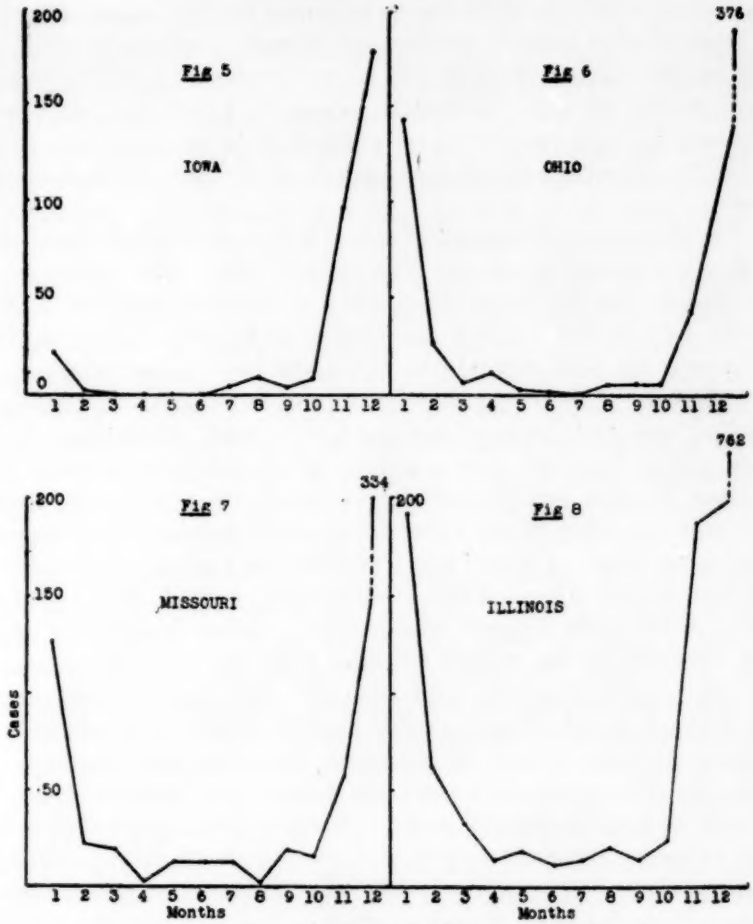
FIGURES 1-4

Total number of human cases of tularemia for each month over a six-year period (1934-39)

such a small number of cases reported in the 4-year period (89) in Michigan, generalizations cannot be made.

In Wisconsin (Table 4, Fig. 2) tularemia in humans has been reported in every month over a 6-year period. March is the low month while October and November are high. This is in direct relationship

TABLE 4 (*Continued*)



FIGURES 5-8

Total number of human cases of tularemia for each month over a six-year period (1934-39)

with the cottontail hunting season which opens in October and closes in February. The slight rise in June may indicate exposure to wood ticks (*D. variabilis*) or the handling of young wild rabbits. During the summer young cottontails are easily caught. During the mowing season, the nests and young are frequently located by farmers. The

snow shoe hare has an open season all year which may account for the cases reported outside of the regular cottontail hunting season. Exposure to other infected animals, hunting out of season, and faulty diagnosis may be other factors. However, the largest number of cases of tularemia occur during the cottontail hunting season in Wisconsin. As human tularemia has been reported in every month there can be no safe period to handle potential tularemia-bearing wild game unless precautions are taken.

The situation in Minnesota (Table 4, Fig. 3) is not very clear. The cottontail hunting season has been open all year until 1939-40. At the present time the Minnesota hunting season is comparable to other North Central States with the season during the winter months. Tularemia has been reported in Minnesota every month during a 6-year period. This would show that precautions should be taken in handling potential tularemia-bearing wild animals. Minnesota has 2 high points; June, 29 cases, and July, 47 cases for the summer; and October, 26 cases, and November, 30 cases for the winter. In comparison with the other North Central States, the reason for the summer peak is not clear. Green (1936) believes the summer peak is due to the deer fly and the wood tick infecting man, and the winter peak by direct contact with infected wild animals. Green (1936) also stated that tularemia in the absence of ticks from November till March is of rare occurrence among wild animals. This does not substantiate the findings in the other 7 North Central States, with tularemia in humans reaching its peak in November, December, and January. In order for infections to take place, the disease most certainly is present in wild animals during the winter. Evans (1939) stated that it was safe to handle cottontail rabbits in midwinter in Minnesota and other northern states. This survey does not substantiate this statement because midwinter is the most dangerous time to handle potential tularemia-bearing wild animals, and precautions should be taken at all times.

Table 4, Fig. 4 shows the total number of human cases of tularemia reported over a 6-year period in Indiana. It is in direct correlation with the cottontail hunting season which opens in November and closes in January. The high months are November, December, and January. No cases have been reported in August, while December totaled 218 cases for the 6-year period. Cases outside of the hunting season may be contributed to factors previously mentioned. As tularemia cannot

be positively diagnosed until two weeks from the entrance of infection, there is some overlapping from one month to the next. Since tularemia has been reported in each month with the exception of August, there is no safe period to handle potential tularemia-bearing wild animals or rabbits without undue caution.

Iowa (Table 4, Fig. 5) follows a typical course for the cottontail hunting season. The high months are October, November, December, and January. The hunting season opens in September and closes in January. More recently the hunting season opens in August and closes in February. No cases have been reported during the months of March, April, May, and June. This is during the wood tick (*D. variabilis*) season, which points to the possibility of rare cases of tularemia by the tick bite. The slight rise in July and August may be due to the wood tick, or other factors previously mentioned. Tularemia in cottontail rabbits occurred in Iowa during the summer and fall of 1939-40. The lack of cases during the four spring months is unknown. It is certainly not safe to handle cottontail rabbits in winter (hunting season) in Iowa without precautions.

Table 4, Fig. 6 shows the total number of human cases of tularemia reported per month over a 6-year period in Ohio. Tularemia has been reported every month with the exception of July. The high months are November, December, and January. This is in exact accord to the hunting season (cottontail) which opens in November and closes in January. Cases outside of the hunting season may be contributed to other factors previously mentioned. Since tularemia has been reported in Ohio every month except July, it is not safe to handle potentential tularemia-bearing wild game without precaution.

Missouri (Table 4, Fig. 7) presented a special problem in this study. Until 1939-40 there has been a continual open season on cottontail rabbits. During the past year the season was closed for 10 days. The high months of tularemia follow those of other states with open hunting seasons in the winter. Missouri's high months are November, December, and January. This would indicate that in Missouri people are inclined to hunt rabbits in the winter. There may be several reasons for this. In Missouri, there is a commercial cottontail rabbit meat industry which supplies food for the eastern market, Leopold (1931). The rabbits are supplied by local hunters during the winter months because of the demand and ease of shipping. This is an important factor

TABLE 5

*Reported cases of human tularemia 1934-39**

	MICHIGAN						WISCONSIN						MINNESOTA						INDIANA					
	34	35	36	37	38	39	34	35	36	37	38	39	34	35	36	37	38	39	34	35	36	37	38	39
Jan.	..	..	..	8	1	..	1	..	1	1	..	..	5	..	..	1	2	..	..	..	..	..	..	14
Feb.	..	..	..	2	..	2	1	..	1	1	1	..	2	1	1	2	1	..	..	..	..	..	2	7
March	..	..	1	4	1	1	..	..	..	1	..	..	2	..	..	1	1	..	1	..	..	..	..	..
April	..	..	..	1	..	..	..	1	..	..	2	..	2	..	..	..	1	..	..	..	..	..	2	1
May	..	..	..	..	..	1	1	1	1	..	3	..	1	4	2	3	2	1	..	..	..	..	2	2
June	..	..	..	4	..	..	4	..	4	2	1	2	6	3	10	5	1	4	..	..	..	..	2	..
July	..	..	..	..	..	1	3	1	1	..	3	..	8	15	10	7	6	1	..	..	..	..	1	..
Aug.	..	..	..	1	1	..	4	..	1	..	2	..	1	7	1	6	1	1	..	..	..	..	..	..
Sept.	..	..	..	..	..	..	7	1	..	..	..	2	5	6	2	1	2	2	1	..	..	..	..	2
Oct.	..	..	..	1	1	..	10	3	2	2	1	6	14	4	3	1	..	4	..	..	..	1	..	6
Nov.	..	..	1	..	3	2	11	8	13	2	10	30	13	5	2	1	2	7	..	..	..	4	8	6
Dec.	..	..	8	4	3	5	3	..	2	1	3	1	3	2	..	..	1	3	2	2	13	28	111	62
Total	..	..	10	25	10	12	45	15	26	10	26	41	62	47	31	28	20	23	4	2	13	33	134	100

TABLE 5 (*Continued*)

	IOWA						OHIO						MISSOURI						ILLINOIS					
	34	35	36	37	38	39	34	35	36	37	38	39	34	35	36	37	38	39	34	35	36	37	38	39
Jan.	1	..	1	..	3	16	7	14	10	21	23	65	12	18	7	41	24	29	27	29	10	34	18	70
Feb.	..	..	..	..	1	2	1	5	1	4	5	8	1	4	1	8	3	4	10	11	6	12	4	26
March	..	..	..	..	..	..	1	..	..	..	4	2	..	13	1	2	1	1	7	5	3	9	2	7
April	..	..	..	..	..	..	2	3	..	2	1	2	2	..	..	..	2	..	..	1	1	2	4	3
May	..	..	..	..	..	..	2	1	..	..	1	..	5	..	1	1	3	3	2	2	..	2	7	4
June	..	..	..	..	..	..	1	..	..	..	..	..	2	2	2	5	..	1	1	1	..	2	..	6
July	..	..	..	..	..	5	..	..	..	..	..	..	..	3	..	2	2	4	1	..	3	3	4	1
Aug.	..	..	1	..	..	7	..	..	3	..	2	..	..	1	..	..	1	1	1	..	1	2	6	9
Sept.	..	..	..	..	..	4	..	..	2	3	..	..	6	..	1	3	2	6	3	1	2	1	5	3
Oct.	2	1	2	..	1	3	1	..	1	1	2	..	4	1	3	3	1	3	5	1	8	..	5	10
Nov.	4	1	9	2	20	52	13	4	7	4	5	13	4	4	22	7	10	16	16	6	8	3	54	93
Dec.	1	..	6	9	82	79	38	34	94	45	106	59	32	1	67	15	121	98	61	12	49	39	350	251
Total	8	2	18	11	107	168	66	61	118	80	149	149	68	47	105	87	170	166	134	69	91	109	459	485

* Data from State Health Reports.

why rabbits are hunted during the winter months in Missouri. Rabbits in the summer have long been known to be "wormy" (*Cysticercus pisiformis, Multiceps serialis,* and *Sarcocystis cuniculi*) or to have "boils" (*Cuterebra* sp.), and are regarded by hunters to be unfit for food. This factor may partly explain why rabbits are not so extensively hunted in the summer. The hunting season of other states is usually in the winter, possibly because of the breeding habits of wild rabbits in the summer. As Missouri has had tularemia reported in every month, reasonable precautions should be taken in the handling of wild rabbits.

Illinois (Table 4, Fig. 8) follows the typical hunting season cycle. The high months for human tularemia are November, December, and January. The cottontail hunting season opens in November and closes in January. Human tularemia has been reported every month in Illinois. Tularemia occurring outside of the hunting season may be due to factors previously mentioned. In Illinois one should not handle potential tularemia-bearing wild game without due caution.

SUMMARY AND CONCLUSIONS

A study of the seasonal occurrence of human tularemia in the North Central States is presented. In general, reported cases of human tularemia have increased in the North Central States. In Michigan, Wisconsin, Indiana, Iowa, Ohio, and Illinois, there is a high correlation between human tularemia and the cottontail rabbit hunting season, which is during midwinter. During this time the chances of human infection are greater due to exposure to many more animals than at any other time. With an all-year open season in Missouri on wild rabbits, the occurrence of human tularemia follows that of the above-mentioned six states. This indicated that people are more inclined to hunt wild rabbits in the winter. The Missouri commercial cottontail rabbit meat industry is an important factor in winter hunting. There are two seasonal periods of human tularemia in Minnesota. The two periods occur in June and July, and later in October and November. The reason for the summer occurrence is not clear. It is thought by some workers to be caused by arthropod vectors. The winter period may be contributed to by exposure to wild rabbits in hunting. In general, human tularemia may be contracted at any time of the year in the North Central States, with the highest number of human cases reported during the winter months or the hunting season. These cases may be caused by arthropod

vectors (10 per cent) or direct contact with infected wild rabbits (90 per cent). When hunting, it is not safe to handle potential tularemia-bearing wild game at any time without precaution.

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CARDIOVASCULAR DISEASES MORTALITY IN A SAMPLE OF WHITE MALES AND THEIR PARENTS[1]

BY ANTONIO CIOCCO

FOREWORD

About five years ago Dr. Raymond Pearl began collecting new material for the purpose of extending his well-known investigations on the constitutional factors associated with health and disease. Some results based on this new material had already been published (Pearl, 1940; Pearl and Moffett, 1939), and the study of the problem discussed in this paper was already broadly outlined at the time of his premature death. Following in some degree the outline of the analysis prepared by Dr. Pearl himself, the writer has sought to bring to a close and to discuss summarily that phase of it already well enough advanced to show the value of the method of approach and of the findings. The writer is grateful to Mrs. Raymond Pearl and to Prof. L. J. Reed for this privilege, and wishes especially to acknowledge the generous assistance of Mr. W. E. Moffett and Mr. J. F. Kish.

INTRODUCTION

THIS paper presents the results of a study to determine if, and to what degree, the frequency of cardiovascular diseases mortality in a group of white males varies in relation as to whether none, one, or both of the parents have died from such diseases. The existence of a familial tendency to diseases of the cardiovascular system has been pointed out by a number of observers. It has been especially remarked with respect to rheumatic heart disease (Read, Ciocco and Taussig, 1938), and a number of pedigrees have been published showing unusual familial prevalence of cerebral hemorrhage (Draper, Allen and Spock, 1939), hypertension (Weitz, 1923), and other conditions affecting the heart and circulatory system. In addition, observations reported by Pearl (1936) and by the writer (Ciocco, 1941)

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reveal that a familial tendency is present relative to the mortality from those diseases involving a break-down of the cardiovascular-renal complex. The study discussed here seeks, therefore, to furnish more data bearing on this tendency in the hope of arriving at a clearer picture of its general and practical meaning for the prevalence of deaths from the diseases considered.

MATERIAL

The records on which this study is based are constituted by (a) copies of the death certificates of a sample of life insurance policyholders who died between 1937 and 1940, and (b) transcriptions of the medical examination and family history obtained on these persons at the time of application for the insurance. These records refer to all the deaths without exception, so far as can be verified, that occurred during 1937, 1938, 1939, and the first 20 weeks of 1940 among the policyholders of the cooperating insurance firm. They number over 11,000; and of them, those utilized for this study were selected according to the following criteria:

1. At the time of application both parents of the policyholder were dead, and the causes of their death were stated specifically, i.e., not expressed in such terms as: old age, sudden, etc.

2. The cause of death of the policyholder also fell into the categories of defined causes.

3. The policyholder was a white male.

The records of 2,309 persons satisfy these criteria and form the material for this analysis.

In coding the causes of death the International List (1938 revision) was followed. Under the heading of cardiovascular diseases are included: cerebral hemorrhage (list No. 83) and diseases of the heart and circulatory system (list Nos. 90-103).

It is obvious that because of the kind of material used and of the method of selection there are characteristics that differentiate the sample of men included in this study from the population at large. The more important of these will be examined first for the policyholders, or index cases as they will be called, and then for their parents. Since the index cases had to be economically prepared and healthy enough in order to be insured and since both parents had to be dead, it results that the range of the age at application or of entry in this experience must be concen-

trated within relatively narrow limits of adulthood. This may be seen from the data given in Table 1 on the distribution of the age at application of the index cases who are classified according to whether they eventually died from cardiovascular diseases or from other causes.

TABLE 1

Age distribution of (a) index cases at the time of application and (b) living persons from Pearl's Family History Records (Pearl and Pearl, 1934; Table 3)*

AGE IN YEARS	INDEX CASES						PEARL'S F.H.R. SERIES	
	Died from cardiovascular diseases		Died from other causes		All			
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
10-19	...	....	...	....	...	....	4	2.94
20-29	37	2.95	42	3.98	79	3.42	12	8.82
30-39	208	16.59	185	17.54	393	17.02	19	13.97
40-49	446	35.57	377	35.73	823	35.64	32	23.53
50-59	418	33.33	346	32.80	764	33.09	40	29.41
60-69	140	11.16	103	9.76	243	10.52	22	16.18
70-79	5	.40	2	.20	7	.30	6	4.41
80-89	...	....	...	....	...	....	1	.74
Total	1254	100.00	1055	100.01	2309	99.99	136	100.00

* Selected because both parents and all four grandparents were dead at time of observation.

Included in the table for purposes of comparison is also the age distribution of a sample of living persons selected at random from Pearl's Family History Records because both of their parents and all four of their grandparents were dead at the time of observation (cf. Pearl and Pearl, 1934). The two series of age distributions have in common that at the time of observation both of the parents of the individuals were dead. They differ, however, principally because the series of this study is composed of individuals all of whom were financially able and healthy enough to be life insurance risks.

From Table 1 it is seen that neither of the two series of age distributions resembles that of the general living population. According to the 1930 census the mean age of the white population is approximately 30 years and, therefore, the two samples are on the average about 20 years older. This difference may be regarded as the consequence of the selective condition regarding parental mortality. Compared to the distribution of the sample from Pearl's Family History Records, the age distribution of this sample of men at the time of their application demonstrates a more restricted range. This probably illustrates the effects of insurability relative to health and economic status. Knowing the peculiarities of this sample it is pertinent to inquire whether they are reflected in the age at death of the index cases and in the frequency of cardiovascular diseases among them. Data on these points are presented in Table 2.

TABLE 2

Mean age at death, actual and expected, of index cases

CAUSE OF DEATH	NUMBER	PERCENT	MEAN AGE AT DEATH	
			Actual	Expected
Cardiovascular diseases....	1254	54.31	64.60 ± .19	71.35
Other diseases.....	1055	45.69	62.86 ± .22	71.17
All index cases.....	2309	100.00	63.80 ± .15	71.27

From Table 2 it appears first of all that 54.31 percent of the index cases died from cardiovascular diseases. In this country during the years 1937 and 1938 cardiovascular diseases caused the death of 42.97 percent of the white males who died at age 30 years and over. So there is a higher prevalence of cardiovascular diseases mortality among the index cases of this sample. This may be due to the elements that entered into the selection of the sample but there are also other factors involved. It will be recalled that only the deaths due to "defined" causes are included among the index cases. Moreover, and of more importance, the distribution of the ages at death by the very nature of the sample is different from that of the general population, even of that of 30 years and over.

With reference to duration of life of the index cases no direct comparable data are, of course, available. It is well to point out that, as is evident from Table 2, the mean age at death is slightly but significantly higher for the cardiovascular group of index cases than for the other. However, the mean expected age at death is practically identical in the two groups. This statistical constant has been computed by adding to the age at admission of each individual the complete expectation of life (e^{o}_{x}) for the age, as given in the 1930 U.S.A. Life Tables for white males. Since the mean expected age at death is practically equal in the two groups, it means that, on the average, the age of entry into the experience is also the same for the cardiovascular and for the other index cases, and this can be easily shown from a comparison of the respective distributions as they appear in Table 1. For both groups of index cases the mean actual age at death seems to be low and is about 7 years less than the mean expected age at death. This difference could possibly be statistical in origin, but it should not be forgotton that the index cases are offspring of persons who relatively speaking had a short duration of life. This may be inferred from a consideration of the criteria of selection of the sample and is demonstrated from the data of Table 3.

TABLE 3

Age at death and frequency of deaths from cardiovascular diseases in parents of index cases

	FATHERS	MOTHERS
Mean age at death	61.81 ± .18	57.63 ± .21
Number	2309	2309
Percent dead from cardiovascular diseases	28.67 ± .006	26.12 ± .006
Number died under 50 years of age	416	661
Percent dead from cardiovascular diseases	7.93 ± .009	8.92 ± .008
Number died 50 years old and over	1893	1648
Percent dead from cardiovascular diseases	33.23 ± .007	33.01 ± .008

It is clearly seen from Table 3 that the fathers and mothers of the index cases died at a much younger age than that observed in the general population. For married and widowed white men and women who died

within the last century the average duration of life is close to 70 years (cf. Ciocco, 1940). Not only were the parents of the index cases short-lived but not a large number of them were said to have died from cardiovascular diseases. Less than 30 percent of the parents died from these causes according to the history given by the index cases, although when only the parents who died at 50 years of age and above are considered the percentage reaches 33. The relatively low incidence of cardiovascular deaths among the parents could be due to inaccurate statements made by some of the index cases but may be quite in order if the duration of life is taken into account.

This somewhat detailed description of the material has been necessary in order to reveal what limitations should be imposed on the generalizations deriving from the results of this study. For the purposes of this investigation the most important attribute of the sample is that the index cases that eventually died from cardiovascular diseases had at the time of application an equal expectation of life duration as did those who died from other causes, and also presumably were as healthy at that time.

CARDIOVASCULAR DISEASES MORTALITY AMONG THE PARENTS AND AMONG THE INDEX CASES

In Table 4 are presented the pertinent values regarding the prevalence of cariovascular diseases mortality among the fathers and mothers of the index cases who did or did not die from these diseases.

It appears immediately that death from cardiovascular diseases was more frequent among the fathers and mothers of men who died from cardiovascular diseases than among the parents of the men who died from other causes. Considering all ages combined, almost 29 percent of the fathers and 31 percent of the mothers of the men who died from cardiovascular diseases had died from these causes as compared to 23 and 26 percent, respectively, of the fathers and mothers of men who died from other causes. The corresponding differences are statistically significant. When only the data on the fathers and mothers who attained the age of 50 are examined the differences between the frequency of cardiovascular diseases mortality among the parents of those who died from these causes and of those who died from other causes is slightly larger and also apparently not due to chance. In the case of fathers and mothers who died younger than 50 years of age the frequency of cardio-

vascular diseases mortality is also higher for the parents of those who died from these conditions. This superiority is not, however, significant statistically.

Since it is observed that both the fathers and the mothers of the men who died from cardiovascular diseases have died with greater frequency from these conditions than the corresponding parent of the

TABLE 4

Frequency of deaths from cardiovascular diseases among the parents of (a) men who died from cardiovascular diseases, and (b) men who died from other causes

CAUSE OF DEATH OF INDEX CASES	ALL AGES AT DEATH		DIED UNDER 50 YEARS OF AGE		DIED AT 50 YEARS OLD AND OVER	
	No.	Percent dead from cardiovascular diseases	No.	Percent dead from cardiovascular diseases	No.	Percent dead from cardiovascular diseases
			Fathers			
Cardiovascular diseases	1254	31.02 ± .009	217	9.68 ± .014	1037	35.49 ± .010
Other diseases	1055	25.88 ± .009	199	6.03 ± .011	856	30.49 ± .011
			Mothers			
Cardiovascular diseases	1254	28.55 ± .009	352	9.66 ± .011	902	35.92 ± .011
Other diseases	1055	23.22 ± .009	309	8.09 ± .011	746	29.49 ± .011

other men, it appears that both father and mother must play an almost equal part in the phenomenon noted. This can be also deduced from the data of Table 5 wherein the mating combinations relative to the deaths from the diseases discussed are presented.

So far as concerns the higher frequency of cardiovascular diseases mortality among the parents of men who died from such causes the data of Table 5 reveal this finding in even more striking form. Almost 10 percent of the index cases that died from cardiovascular conditions were offspring of parents both of whom had died from these diseases. This is found for only 6 percent of the other index cases. In contrast,

among the latter 57 percent were offspring of parents neither of whom had died from cardiovascular diseases as compared to 50 percent of the index cases dead from cardiovascular diseases. When a chi-square test is applied to determine if the two series of parental mating combinations are significantly different, the chi-square equals 15.7 and $P = .001$. Although the percentages have different values, the same general results are evident if only the distributions concerning parents both of whom died at 50 years or over are analyzed. Therefore, it seems rather definite that in this sample the parents of men who died from cardiovascular diseases have died more often from causes involving a breakdown of this system than the parents of the men who died from other causes.

TABLE 5

Frequency of parental matings involving (a) neither parent dead from cardiovascular diseases, (b) father only dead from cardiovascular diseases, (c) mother only dead from cardiovascular diseases (d) both parents dead from cardiovascular diseases

PARENTAL MATINGS*	TOTAL SAMPLE				BOTH PARENTS DIED AT 50 YEARS OLD OR OVER			
	Cause of death of index cases				Cause of death of index cases			
	Cardiovascular diseases		Other diseases		Cardiovascular diseases		Other diseases	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
♂ o × ♀ o	627	50.00	602	57.06	321	41.10	303	48.40
♂ c.v. × ♀ o	238	18.98	180	17.06	173	22.15	138	22.04
♂ o × ♀ c.v.	269	21.45	208	19.72	178	22.79	127	20.29
♂ c.v. × ♀ c.v.	120	9.57	65	6.16	109	13.96	58	9.27
Total	1254	100.00	1055	100.00	781	100.00	626	100.00

* c.v. indicates death from cardiovascular diseases.
o indicates death from other diseases.

In passing it may be remarked that taking all parents together the mating combination of both parents dead from cardiovascular diseases is found more often than expected on the basis of random assortment. Since 28.7 percent of the fathers and 26.1 percent of the mothers had died from these diseases, it would be expected that among the 2,309 couples 173 would be composed of a husband and wife both of whom had died from diseases discussed. Actually there are 185. This difference could be due to chance. t is here remarked because in a recent investigation regarding deaths from cardiovascular-renal diseases in marital couples the writer observed a higher number than expected of husbands and wives both of whom had died from the diseases. Again the difference between actual and expected was not statistically significant. However, when only deaths from diseases of the heart (list Nos. 90-95) were studied a significant marital concurrence was observed.

CARDIOVASCULAR DISEASES MORTALITY OF OFFSPRING IN RELATION TO MORTALITY OF PARENTS

Due to the nature of the material an attempt can be made to arrive at some answer to the fundamental question regarding the variation in the chances of dying from cardiovascular diseases when one or both

TABLE 6

Frequency of deaths from cardiovascular diseases among the index cases, and parental matings

MATINGS* OF PARENTS OF INDEX CASES	INDEX CASES		
	Number	Mean expected life duration at application (in years)	Percent dead from cardiovascular diseases
♂ o × ♀ o	1229	23.70	51.02
♂ c.v. × ♀ o	418	23.83	56.94
♂ o × ♀ c.v.	477	23.53	56.39
♂ c.v. × ♀ c.v.	185	23.11	64.86

* c.v. indicates death from cardiovascular diseases.
o indicates death from other diseases.

parents have died from these diseases. By simply transforming the data given in Table 5 the results shown in Table 6 are obtained.

Thus the index cases are segregated into four groups according to whether (a) neither father nor mother allegedly died from cardiovascular diseases, (b) only the father, (c) only the mother, and (d) both of the parents died from these conditions. At the time of application these four groups of individuals presumably were all equally in good physical health. Their ages were about equal on the average and as is seen in Table 6, their average life expectancy was therefore about the same. However, when they eventually died the groups differed with respect to the incidence of one of the cardiovascular diseases as a cause of death. Among the men who had stated that diseases other than those of the cardiovascular system had caused the death of both parents, 51 percent died from a breakdown of the heart and circulatory system. Of the men whose fathers only had died from these diseases, 57 percent died from the same group of causes. Almost the same percentage (56 percent) is found relative to the mortality of the men whose mothers only had died from the cardiovascular diseases. Further, 65 percent of the index cases died from these diseases in the group composed of men both of whose parents had died from cardiovascular diseases. Therefore, on the basis of this sample it appears that associated with a history of cardiovascular diseases mortality in one parent, either father or mother, there is an increase by an amount equal to about 11 percent of the frequency of mortality from the same causes in the offspring. When there is a similar history regarding both parents the increase amounts to over 27 percent. It is, of course, understood that these figures represent estimates valid for the sample as selected, nevertheless they point out effectively and in a new manner, the significance of the familial factor in the mortality from the group of diseases that constitutes the most important cause of death.

DISCUSSION

These findings reveal again and in a rather impressive way the familial tendency towards a fatal breakdown of the heart and circulatory system. It has been shown that more fathers and mothers of men who died from cardiovascular diseases died from these causes than the parents of men who died from other diseases. Moreover, the findings also suggest that at equal exposure to risk the frequency of cardiovascular diseases mortality among offspring increases in order according to

whether none, one, or both of the parents have died from these diseases. Consideration of these findings lead first to the examination of the possible or probable hypotheses that can be advanced regarding the factors involved. The least probable factor is that of contagion from parent to offspring. Of the major etiological types of heart diseases only in the case of rheumatic heart disease is it possible that the element of contagion may play some part. Yet, at the time of application the parents of the index cases were already dead and the index cases themselves had reached adulthood and were presumably in good health. One could postulate a common environmental condition for the parents and their offspring but in view of the above reflections this explanation is also not satisfactory and particularly because the frequency of cardiovascular diseases mortality among the offspring when both parents are affected is double that when one parent only is affected. It appears more probable, therefore, that here is exemplified a manifestation of the hereditary transmission of an organ weakness, that is, a constitution less resistent to whatever immediate factors cause cardiovascular diseases. The observations reported by many investigators regarding the somatological constitution and the familial concentration associated with the several forms of heart and circulatory diseases (cf. Campbell, 1934; also Ciocco, 1936) all agree with this inference. It seems safe to conclude that the findings of this study support further the presumption that the innate biological constitution plays possibly a decisive rôle as a factor in the etiology of cardiovascular diseases.

These figures on the frequency of cardiovascular diseases mortality among the offspring in relation to the prevalence of these causes of death among the parents provide for the first time a measure of the immediate practical meaning of the familial tendency studied. That frequency, as has been shown, increases by 11 percent in the case of one parent dead from these causes to 27 percent when both parents died from them. If these figures approximate at all the true measure of the phenomenon the increment is obviously substantial, especially recalling the high incidence of mortality from cardiovascular diseases in the population. These findings thus demonstrate once again the public health value of studying diseases, the chronic diseases particularly, from the standpoint of the familial aggregate. Not only can the effects of the immediate environment: diet, sanitation, etc., be evaluated but also those of the genetic constitution. With respect to the latter it deserves to be noted here that because of the pronouncements of certain missionary

eugenists of the past it is the belief of some medical men and public health students that, if the genetic factor is significant in the incidence of a disease, preventive measures other than selective breeding cannot be attempted. This belief derives in part from "the fallacy that showing a characteristic to be hereditary proves that it is not alterable by environment" (Jennings, 1930). It is known instead, that even for extraordinary conditions, hemophilia, for example, care to prevent the fatal manifestations of the inherited constitution can be instituted. Therefore, it is hoped that results such as these discussed in this paper will lead to the realization that for certain diseases a positive family history in an otherwise apparently healthy person may have the same meaning as a positive tuberculin reaction in some cases. That is, it is a forecasting sign indicating the probable need for special care and observation. From such a realization the impetus will be derived for closer cooperation between the geneticist, the epidemiologist, and other medical scientists in their attempts to solve some of the many problems connected with public health and disease prevention.

SUMMARY

From the records regarding the causes and ages of death of 2,309 male life insurance policyholders who died between 1937 and 1940, an analysis regarding cardiovascular diseases mortality in the index cases (the policyholders) and their parents was initiated by the late Raymond Pearl. The results of this analysis completed by the writer reveal:

1. Among the index cases that eventually died from cardiovascular diseases, 31 percent of the fathers and 29 percent of the mothers had died from these diseases. The corresponding percentages for the index cases that eventually died from other causes are 26 and 23.

2. Both the father and mother of 10 percent of the index cases that died from cardiovascular diseases had died from these causes, but cardiovascular diseases caused the death of both of the parents of 6 percent of the index cases dying from other causes. In contrast, 57 percent of the latter had stated that neither parent had died from cardiovascular diseases as compared to 50 per cent of the index cases that died from the diseases discussed.

3. The frequency of cardiovascular diseases death among the index cases equalled 51 percent when neither parent had died from these

causes, it rose to 57 percent when only the father had died from cardiovascular diseases, and 56 percent when only the mother had been so affected, and it rose further to 65 percent when both parents had died from these diseases.

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FURTHER EVIDENCES OF REVERSAL IN THE HUMAN GROWTH TIDE

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TWO years ago we presented evidence that the long-continued upward trend in the stature of college freshmen was showing signs of tapering off or of actual reversal (1). Height of University of Cincinnati freshman girls had been practically stationary for the last ten years, while that of the boys had actually turned downward after the entering class of 1934. The march of the girls' menarchial age toward ever earlier years also seemed to have been checked. This turning of the human growth tide we considered as perhaps based upon the rising environmental temperature levels so commonly prevailing through recent years.

Growth and speed of development in experimental animals show a striking dependence upon tissue combustion rate and ease with which body heat can be dissipated. Optimal growth seems to require an active tissue combustion level just as truly as does the performance of other types of work. The body being only 20—25 per cent efficient as an energy conversion machine, and being very sensitive to the internal accumulation of heat (fever), it must and does bank its internal fires when any prolonged difficulty in heat dissipation is encountered. And accompanying this metabolic suppression we find a coincidental reduction in rate of growth and development, a lessened resistance to infection and production of immune bodies, and a drop in energy available for thought or action. Standard intelligence tests result in much lower ratings when given in summer heat than if given during winter cold. This dependence of many basic body functions upon ease of body heat loss seems now to be a true finding, and to exert important influences throughout life (2).

Implications of rather profound racial significance will attach to any findings clearly indicating that man is thus dominated by his environmental temperature in the same way as are experimental animals. Mental,

as well as physical, changes accompany fluctuations in the ease of body heat loss, for oxygen consumption is many times higher in the grey matter of the brain than in any other body tissue. Intelligence tests given in summer heat result in ratings only about 60 per cent as high as those obtained during winter cold. And during whole years of unusual warmth, population masses give several indications of a lowered plane of existence (3). World temperatures have shown an irregular rising trend for almost a century now (4), at a time when another of the recurring milleniums of warmth is about due to return (5). We have been much interested, therefore, in watching for any physical changes in man that might indicate a reversal in the prolonged upward growth tide of recent centuries. Any reversal toward lower levels of existence in human energetics with rising world temperatures would carry implications of great importance to man's future, if world temperatures should really be entering another of the recurring long periods of warmth. The clear-cut responses given by warm-blooded laboratory animals to changes in ease of body heat loss leads us to believe that man will be found quite similarly affected.

In looking for significant changes in man, three types of data were sought: (a) height-weight values for different age groups, (b) menarchial data on girls, and (c) intelligence test ratings. Statistics along the first two lines have been obtained in ample amounts from college freshmen and high school students, where standard forms of history taking and physical examination have prevailed for some years. On the third point, however, little useful information was obtained relative to time changes in intelligence ratings. Frequent alterations in the types of tests used effectively prevent an evaluation of any changes that might take place from decade to decade. Many educators have professed to see a reduction in student intelligence in recent years, but such an impression is highly subjective in nature and of little scientific value unless confirmed by purely objective data.

The present study is limited, therefore, to height, weight, and menarchial data on college freshmen and on high school students. Through the courtesy of the various college health authorities in making their records available, statistics were obtained on freshmen enterign four state universities (Kentucky, 1925-1938; Kansas, 1928-1938; Wisconsin, 1928-1939; and the Women's College of the University of North Carolina, 1912-1938). Only state universities that draw their students largely from rural populations were selected for the study, so that valid com-

TABLE 1

Menarchial age of university girls by year of birth

YEAR OF BIRTH	N. CAROLINA		KANSAS		CINCINNATI		WISCONSIN	
	Menarchial age in yrs.	No. of cases	Menarchial age in yrs.	No. of cases	Menarchial age in yrs.	No. of cases	Menarchial age in yrs.	No. of cases
–1890	14.16±0.051	347	.....	...	.....	...	14.29±0.182	43
1891–5	14.15±0.024	1179	.....	...	.....	...	13.87±0.064	197
1896–00	14.05±0.020	1598	13.69±0.35	621	13.71±0.061	194	.....	...
1901–05	13.98±0.017	2321	.....	...	.....	...	13.83±0.059	243
1906–10	13.85±0.015	3163	.....	...	.....	...	13.63±0.36	645
1911	13.59±0.040	390	13.62±0.047	363	13.69±0.063	178	13.62±0.050	294
1912	13.65±0.030	700	13.67±0.034	533	13.56±0.059	178	13.51±0.044	506
1913	13.71±0.031	619	13.45±0.044	368	13.56±0.050	252	13.62±0.030	807
1914	13.61±0.032	629	13.54±0.049	356	13.39±0.047	286	13.44±0.029	918
1915	13.54±0.032	563	13.44±0.048	318	13.38±0.044	301	13.47±0.028	901
1916	13.52±0.033	536	13.38±0.049	269	13.33±0.044	281	13.36±0.028	991
1917	13.42±0.032	641	13.32±0.048	274	13.31±0.046	303	13.34±0.028	986
1918	13.31±0.030	669	13.20±0.051	291	13.20±0.045	339	13.29±0.025	1098
1919	13.34±0.029	621	13.15±0.049	295	13.09±0.049	246	13.28±0.026	967
1920	13.35±0.030	600	13.23±0.060	233	13.20±0.054	277	13.26±0.028	896
1921	13.40±0.034	476	.....	...	13.13±0.047	258	13.22±0.030	775
1922	13.42±0.086	59	.....	...	.....	...	13.23±0.050	280

parisons might be made at different latitudes. Not all the freshman records were used, only those being taken that gave complete data on the particular points of interest. With the girls, only those giving menarchial age were included. Height and weight records were taken only for the 16, 17, 18, and 19 year old freshmen. It would seem reasonable to conclude, however, that the findings obtained with the large number of records used might apply equally well to all freshmen matriculating in these state universities.

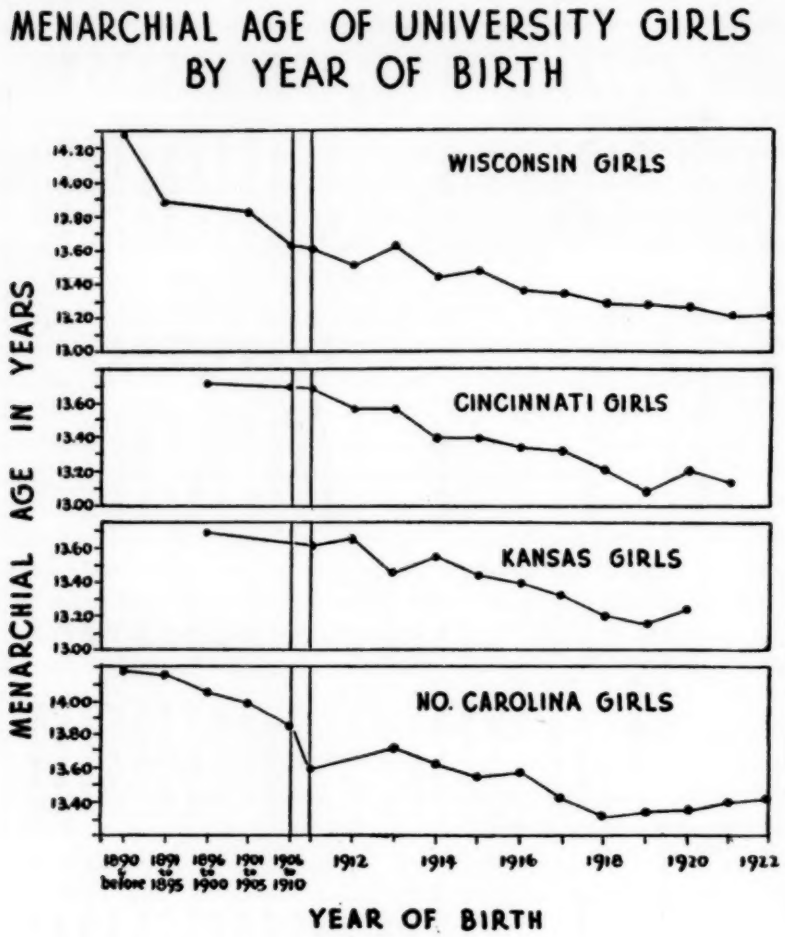

FIGURE 1

CHANGES IN MENARCHIAL AGE

Table 1 and Fig. 1 present statistics on the changes in menarchial age that have occurred in recent decades. In the southernmost school of the group, the long trend toward earlier menarche seems to have been reversed with those girls born in 1919; since then, each year's freshman group has evinced a progressively later menarchial age. While the degree of change is small and not yet mathematically significant, its persistance is indicative that a real reversal of trend is taking place. Farther to the north, evidences of reversal are less definite and later in appearance, but in each college group the younger members of the class no longer have the earliest menarche—as they did during all the years when the trend toward earlier menarchial age was so strongly in evidence. The menarchial data from any one school alone would be much less convincing, as to any oncoming reversal, than is the coincidental character of the evidence from all the schools.

The reversal appeared in North Carolina with the girls born in 1919, while in Cincinnati and Kansas it came with births of 1920. In Wisconsin it came still later, in 1922, but records of the whole 1939 entering class of Wisconsin girls showed a later mean age for onset of the menses than had the preceding class. Further observation through the years to come will be of great interest in substantiating these present indications of reversal, but so far it does seem that our predictions of change in trend, made in 1938 (1), are being borne out.

HEIGHT-WEIGHT CHANGES

The data given in Tables 2 and 3 indicate the height and weight changes that have taken place in 16, 17, 18, and 19 year old college freshmen of recent entering classes. Students entering the schools located at lower latitudes are combined in Table 2, while those of Wisconsin are given separately in Table 3 to represent trends at higher latitudes. Figs. 2 and 3 present graphically the height-weight changes in 16-19 year combined age groups.

With the male freshmen of Kansas and Kentucky, the height improvement of past decades continued up to 1932 or 1933 for all age groups, but the last six years have witnessed a fairly consistent subsidence to slightly shorter stature at all ages. Gain in male weight has also been inconstant and negligible since the entering class of

TABLE 2

Stature changes in university freshmen Universities of Kansas, Kentucky, and North Carolina (Woman's College only)

YEAR OF MATRICULATION	BOYS (Kansas and Kentucky only)									
	Height in inches (by age groups)					Weight in pounds (by age groups)				
	16 yr. olds	17 yr. olds	18 yr. olds	19 yr. olds	All	16 yr. olds	17 yr. olds	18 yr. olds	19 yr. olds	All
1928	68.28	68.59	68.67	68.94	68.72	131.67	136.17	138.89	142.75	139.23
1929	68.11	68.57	68.71	68.42	68.55	133.64	137.63	140.56	140.40	139.71
1930	68.31	68.82	68.85	68.71	68.78	133.52	138.27	141.21	140.10	139.79
1931	68.24	68.71	68.88	68.66	68.75	132.83	137.67	140.63	142.80	140.93
1932	69.06	69.24	69.17	69.36	69.23	141.40	140.92	141.88	143.84	142.12
1933	68.38	69.17	68.94	69.42	69.12	131.15	139.80	140.11	145.25	141.23
1934	68.02	69.06	69.14	69.09	69.08	138.81	139.68	142.52	141.87	141.87
1935	68.07	69.13	69.16	69.19	69.08	136.05	139.75	144.17	142.95	142.32
1936	68.88	69.06	68.97	69.07	69.01	137.81	139.52	142.32	142.78	141.62
1937	68.66	69.02	69.25	69.13	69.05	140.95	139.61	144.98	145.91	143.60
1938	68.61	69.24	69.06	68.79	69.03	136.11	141.78	143.12	143.18	142.53
	GIRLS (Kansas, Kentucky, and North Carolina)									
1928	64.07	64.25	63.83	63.87	64.01	117.13	117.20	116.94	115.69	116.79
1929	64.74	64.01	65.01	63.65	63.99	118.16	117.07	117.19	118.16	117.49
1930	64.01	64.01	63.88	63.70	63.92	118.38	118.61	117.77	117.09	117.91
1931	64.28	64.22	63.80	64.06	64.03	116.41	119.22	118.25	120.19	118.87
1932	63.86	64.21	64.04	63.86	64.06	117.24	121.67	119.36	117.19	119.55
1933	64.55	64.10	64.09	64.15	64.12	120.46	118.29	116.95	117.95	118.02
1934	63.89	64.26	64.05	64.27	64.25	118.56	120.65	117.84	119.43	119.44
1935	64.14	64.20	63.98	64.27	64.19	120.24	119.49	117.73	119.90	119.08
1936	64.57	64.06	64.01	64.03	63.74	121.07	119.36	120.82	116.90	119.45
1937	64.40	64.06	64.11	64.07	63.11	120.38	119.46	119.19	117.65	119.18
1938	64.24	64.34	64.31	64.06	64.29	120.53	119.69	120.46	120.77	120.15

TABLE 3

Stature changes in university freshmen
University of Wisconsin

YEAR OF MATRICULATION	Height in inches (by age groups)					Weight in pounds (by age groups)				
	16 yr. olds	17 yr. olds	18 yr. olds	19 yr. olds	All	16 yr. olds	17 yr. olds	18 yr. olds	19 yr. olds	All
BOYS										
1928	67.59	68.62	68.86	68.72	68.71	132.44	140.07	143.30	141.72	141.58
1929	67.84	68.86	68.97	68.91	69.15	131.67	141.69	143.84	144.42	143.03
1930	68.40	68.76	68.64	69.71	68.68	135.24	142.37	142.62	145.75	143.28
1931	69.19	69.51	69.08	68.92	68.87	139.63	139.00	143.66	144.29	142.46
1932	68.64	69.45	69.80	69.51	69.62	133.57	143.87	144.25	147.76	144.83
1933	69.27	69.36	69.77	69.70	69.53	134.03	140.41	144.45	145.68	143.45
1934	68.92	69.41	69.86	69.45	69.61	141.54	144.93	145.97	147.53	145.98
1935	69.12	69.68	69.75	69.49	69.60	142.11	144.90	145.09	146.61	145.36
1936	69.11	69.88	69.94	69.85	69.63	140.45	145.25	146.48	147.86	146.42
1937	69.95	69.59	69.73	69.88	69.74	145.00	145.79	145.56	148.01	146.17
1938	69.91	69.97	70.20	69.98	70.01	139.48	146.20	147.58	149.50	147.75
1939	70.56	70.10	70.19	70.35	70.21	156.18	146.47	147.47	148.17	147.48
GIRLS										
1928	63.99	64.11	64.13	64.05	64.10	119.10	120.34	121.80	118.83	120.59
1929	64.29	64.04	64.40	64.44	64.32	125.43	123.27	122.80	121.59	122.35
1930	63.44	64.62	64.40	64.14	64.16	120.29	127.35	124.47	120.36	119.18
1931	64.18	64.08	63.78	64.03	63.96	123.38	121.97	121.06	123.74	122.02
1932	63.77	64.02	64.06	63.74	63.96	123.61	121.82	120.86	124.62	121.97
1933	64.09	63.74	63.87	64.12	63.89	125.26	121.21	122.14	120.36	121.62
1934	64.82	64.30	64.25	64.29	64.29	119.21	124.22	121.70	121.26	122.27
1935	63.94	64.07	64.13	63.81	64.04	132.31	124.03	122.77	121.30	123.23
1936	64.07	64.53	64.09	64.47	64.30	125.27	123.09	122.53	123.16	123.24
1937	64.24	64.33	64.22	64.11	64.26	125.47	124.13	123.81	122.68	123.70
1938	64.22	64.38	64.31	64.44	64.35	123.00	125.48	124.59	124.63	124.89
1939	63.92	64.54	64.61	64.76	64.59	119.85	124.78	125.98	124.89	125.77

1932. In only one year (1932) did the height of the 16 year old boys come close to the class average, and that year's figure is so far out of line with immediately preceding and succeeding values as to appear an artifact, based upon inadequate numbers (only 25 cases). A maximum in height and weight appears to have been reached in 1932, with a marked subsidence after the intense and prolonged heat of the 1934 summer, and followed by a later secondary peak (1936 in height, 1937

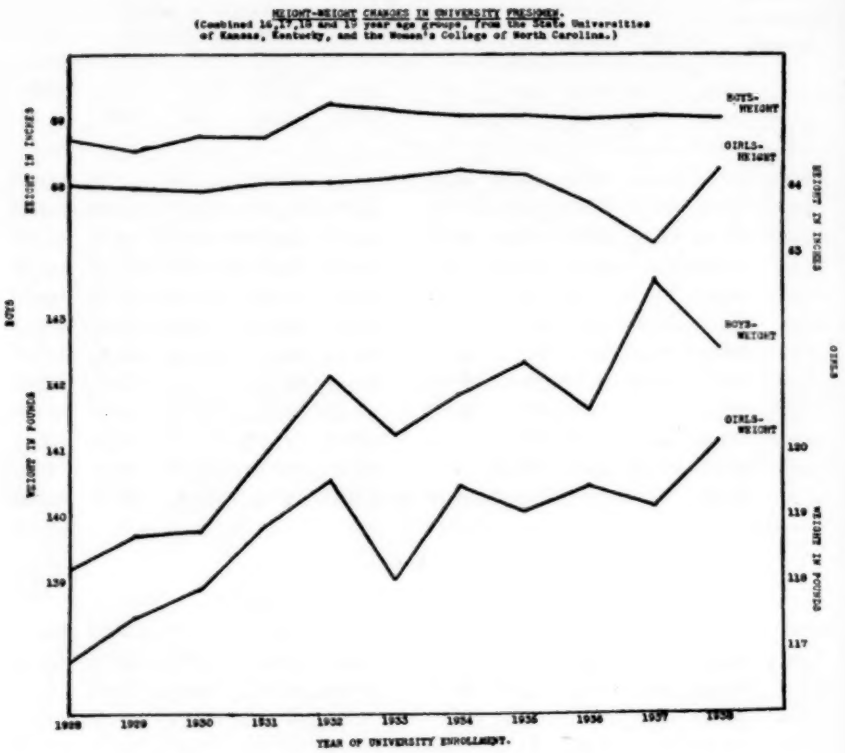

FIGURE 2

in weight) and subsequent further decline toward lower levels. There would now seem to be little future likelihood of the 16 year old group overtaking in development those of older ages. This is in sharp contrast to the Wisconsin findings discussed in a subsequent paragraph.

Female freshmen in Kansas, Kentucky, and North Carolina have shown no significant tendency to height improvement, at any age, during

the past eleven years. Earlier puberty in the girls has brought complete skeletal development by the age of 16 years. In weight, however, the girls exhibited gain up to 1932, recession through the years of severe summer heat, and a subsequent maximum in 1938. In eight out of the eleven years, the 16 year old girls have been heavier than the class average.

Wisconsin girls have shown much the same completeness of growth at the age of 16 as did those in the more southern states. Again, in

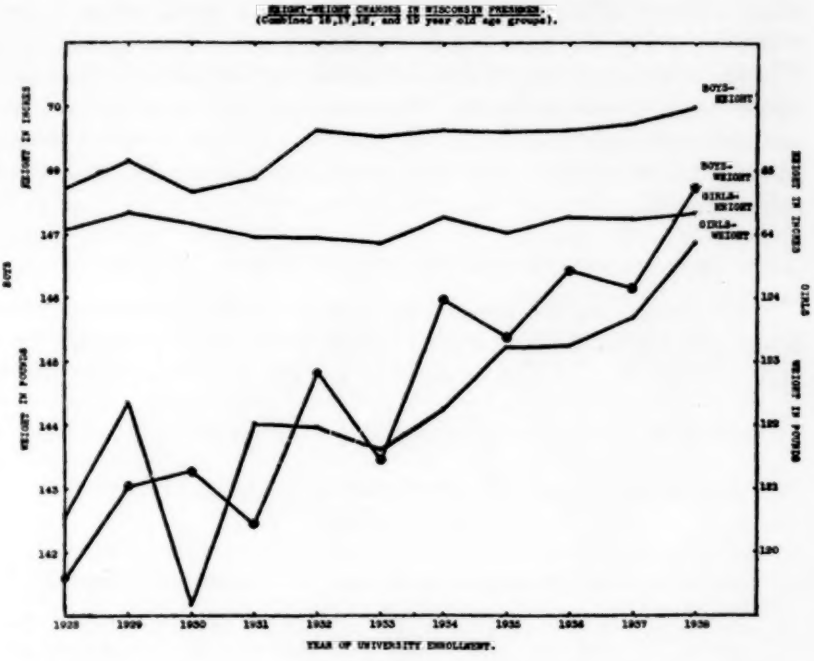

FIGURE 3

eight out of the eleven years, the 16 year olds were heavier than the class average. The 16 year old girls' height average for the whole eleven years is only 0.1 inch less than that of the whole group, and in no age group is there any significant tendency to further height improvement except in the most recent year's class (1939). The early height maximum in 1929 was not again equalled until 1938, with almost ½ inch recession and recovery in the intervening years. With

Wisconsin boys, however, quite a different picture is presented. Every age group has improved markedly, and is still improving, in both height and weight. Gain in height during the twelve years studied has amounted roughly to 1½ inches for the 17, 18, and 19 year old groups, *while the 16 year old group has increased almost 3 inches* and has now overtaken the older age in both height and weight. Word received by correspondence with observers at Harvard, Yale, and the University of Toronto indicate about the same male stature development and continuing increase as shown here for Wisconsin. In these more northern latitudes of greater physical vigor, there are as yet no evidences of physical recession in the male youth. Average height at Wisconsin is an inch greater than in Kansas and Kentucky, and average weight about 5 pounds higher. Wisconsin girls are 5 pounds heavier and about 0.6 inch taller than are those of the more southern states, although neither group of girls any longer shows a tendency to further height increase.

HEIGHT-WEIGHT CHANGES IN HIGH SCHOOL STUDENTS

Since female stature seems well stabilized before college matriculation, and that of the men almost equally so in recent years, we went back to earlier junior high school ages for the more immediate effects

TABLE 4

*Height-weight changes in school children. Changes in stature of school children**

YR. OF EXAMINATION	HEIGHT IN INCHES				WEIGHT IN POUNDS			
	13 yr. old boys	14 yr. old boys	13 yr. old girls	14 yr. old girls	13 yr. old boys	14 yr. old boys	13 yr. old girls	14 yr. old girls
1938	61.70	63.62	62.48	62.77	102.86	111.47	103.89	109.35
1937	61.42	63.55	61.65	62.62	98.40	111.05	104.41	109.75
1936	61.59	63.83	61.40	62.10	101.98	110.69	104.89	*106.09*
1935	61.58	63.43	61.37	*61.60*	99.93	*108.25*	*100.81*	109.90
1934	*59.67*	*62.86*	*60.63*	62.32	*93.03*	*107.86*	*101.00*	109.34
1933	60.20	63.29	61.99	61.55	97.44	110.00	102.82	101.67
1932	59.67	62.75	....	....	96.67	111.67	.....	92.50

* These figures do not represent measurements on a given group of children during successive years, but are the mean values for all children of the given age groups measured in each year of the series.

of severe summer heat upon body growth. Table 4 presents mean height and weight values on over 1800 13 and 14 year old children, obtained from the records kept at one of the largest Cincinnati high schools. This school is located in a well-to-do residential district where actual malnutrition during the severe depression years would have been likely to play practically no part in childhood growth changes. Here we see a sharp set-back in both height and weight of the 13 year old children after the unusually severe and prolonged summer heat of 1934. The set-back showed up promptly in the 13 year old groups of both sexes, but with the 14 year olds it tended to show up more in the succeeding year. This lag in appearance may possibly mean that the heat exerts its depressing effects more at the age of 13, when growth is more rapid, than a year later when it has begun to slow down somewhat.

Incidentally the data of Table 4 also show that even back at the age of 14 years the yearly improvement in stature has almost ceased in Cincinnati children. Each year's crop of 13 year olds still shows some tendency toward betterment over the standards of previous years. Back at 9 and 10 year ages, each year's crop still shows marked height and weight improvement over preceding levels. It would seem that, at least in middle temperate latitudes, acceleration of growth and development is becoming more truly a phenomenon of childhood years, with an increasing stabilization during youth, and a probable oncoming recession in adults.

DISCUSSION

Human statistics do seem, therefore, to bear out the animal findings as to ease of body heat loss dominating body growth and development. The unseasonal warmth that prevailed so generally over the earth from 1930 to 1936, accompanied in several of the years by severe and prolonged summer heat waves, seems to have brought about a definite set-back in the growth and development of American youth living in middle and lower temperate latitudes. Farther north, where summer heat waves are of short duration, few evidences of retardation are to be found as yet. Fig. 4 depicts this growth recession in the 17 year old Kansas girls, and represents the type of human response we would like to find in all the statistics collected. Instead of such striking response, we must be content with much less clear-cut findings when

dealing with large numbers of students of different ages and different regions. Development of college freshmen represents the summation of a variety of growth factors acting through many years of childhood and youth. Any change in adult stature will necessarily be slow in developing, more like the ponderous turning of a tide than like the

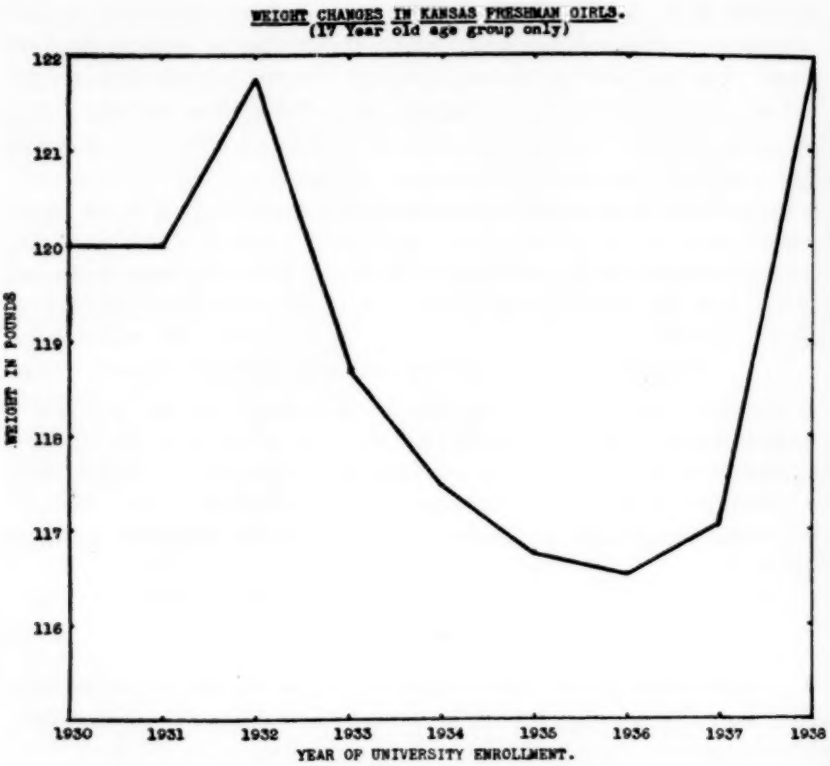

FIGURE 4

quick responses we can obtain on experimental animals under controlled conditions. Changes in external temperature levels, if the heat be sufficiently severe, may bring on immediate growth retardation in childhood, but several years are required to make the effects evident in college student stature.

Earth temperatures have been trending upward for the past eight decades or so, but it is really only in the last ten years that severely

depressive heat conditions came to middle and lower temperate latitudes summer after summer. The human growth tide progressed apace through the early decades of rising world temperature levels, but now it seems perhaps to be turning to ebb as summer heat reaches more critical levels. There was, of course, great improvement in the American dietary during this period of great growth improvement, and this factor may well have played an important part in determining the extent of the improvement. Similar growth betterment has been observed in every country of the earth where statistics have been collected, and in most instances has been credited by nutritionists to a better dietary and more hygienic type of existence.

But the American dietary, especially among families sending children to college, has never been better than in the recent years when the growth tide seems to be reversing itself. With experimental animals, no kind of dietary change seems capable of overcoming the growth-depressing effect of environmental heat. The body must generate more heat in using more food, and sufficient difficulty in dissipating this extra heat will inevitably result either in curtailment of combustion rate or else in death from hyperpyrexia. Animals kept at 65°F. eat over twice as much food as do those kept at 90°F. With change from the cool to the hot environment, their food consumption and growth rate immediately decrease. Animals living at 65°F. will starve to death in a few days if given daily only as much food as those living at 90°F. consume. We stress these animal findings because of their very direct bearing upon the dynamics of growth, and because of the impossibility of approaching the problems of human growth from the same direct experimental angle.

Earth temperatures since 1937 have shown the falling tendency usually accompanying the more active phases of the so-called 11-year sunspot cycle. Sunspot activity has been high throughout most of the past 3 years and American temperatures have dropped considerably from their 1930-1936 levels. Even so, mean temperatures of a majority of the months are still above the long-term normal level. Summer heat has been much less severe in the last 3 years, however, and this may account for the stature improvement in the 1938 entering class of Kansas, Kentucky, and North Carolina girls (Fig. 2) and that indicated by a preliminary survey of the North Carolina entering class of 1939. A recent study by DuBois and Hardy (6) has shown that women

are less able than men to withstand difficulty in heat loss (temperatures above 82°F.), and it may be this that explains the more marked response of female stature to depressing heat as shown in Fig. 2.

If the same relationship that we have been able to show for experimental animals, can be definitely established between human development and ease of body heat loss, then we must perforce become much interested in future world temperature trends. Further extension of the temperature rise of the past eight decades might conceivably induce a profound racial downturn in the densely populated region of middle and lower temperate regions. Here lies the basis for an impelling human interest in the causation and behavior of sunspots, and in the relationship they seem to bear to world weather and mean temperature levels.

SUMMARY

A reversal seems to have occurred in the march of the menarche toward ever earlier ages. The change toward later menarchial age occurred in North Carolina with girls born in 1919, in Kansas and at Cincinnati with births in 1920, and in Wisconsin with girls born in 1922.

Year by year improvement in stature of college freshmen, which also had been in evidence for several decades, now seems to have ceased in middle and lower temperate latitudes. Actual recession in freshman stature occurred during the recent years of unusually severe summer heat, this recession showing up even more clearly in 13 and 14 year old school children following the prolonged heat of the 1934 summer.

While all age groups of male freshmen at higher latitudes (Wisconsin) still continue some yearly stature gain, this gain is most marked in the 16 year olds. *This group has gained 3 inches in height during the past eleven years,* and now is practically as tall as the 19 year old group. This is not true of boys farther south at the University of Kansas, where improvement has ceased with all age groups and with the 16 year olds still considerably inferior to those of 19 years.

Height of freshman girls is practically the same for all age groups studied (16 to 19 years), indicating a completion of skeletal growth by the age of 16 years. Female height has been stabilized for some years past, except for a distinct recession in lower latitudes following the years of severe summer heat (1934-6).

From these studies it would seem that growth improvement has now become largely a matter of more rapid growth through childhood, with stabilization or actual recession in final adult stature appearing in lower temperate latitudes and encroaching northward.

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MENTAL AND PHYSICAL DEVELOPMENT AS INFLUENCED BY SEASON OF CONCEPTION

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VARIOUS statistics presented by Huntington (1), Petersen (2), and others (3, 4, and 5) have indicated that the season of conception plays an important part in a child's future development—in his chances of achieving distinction and in his average life span. Parental vigor at the time of conception seems to be carried over in the germ plasm, and to affect the metabolic level upon which the new individual shall go through life. Biologic measurements of this seasonal effect upon development have been lacking, however, since most of the studies dealt only with birth statistics of notable persons listed in various *Who's Who* volumes.

In the following pages are presented height, weight, and menarchial data on over 45,000 freshmen enrolling in certain American colleges. These data indicate an undoubted influence of season of conception over the later development of the individual. The likelihood of college matriculation is about 60 per cent greater with children conceived during the winter season than with those conceived in the summer heat. Winter conception also results in significantly earlier onsets of the menses in girls. Curiously enough, winter conception seems also to result in slightly inferior adult stature.

Through the courtesy of the various college health authorities in making their records available, statistics were obtained on freshmen entering four state universities (Kentucky, 1925-1938; Kansas, 1928-1938; Wisconsin, 1928-1939; and the Woman's College of the University of North Carolina, 1912-1938). Only state universities that draw their students largely from rural populations were selected for the study, so that valid comparisons might be made at different latitudes. Not all the freshman records were used, only those being taken that gave complete data on the particular points of interest. With the girls, only

those giving menarchial age were included. Height and weight records were taken only for the 16, 17, 18, and 19 year old freshmen. It would seem reasonable to conclude, however, that the findings obtained with the large number of records used might apply equally well to all freshmen matriculating in these state universities.

SEASON OF CONCEPTION AND LIKELIHOOD OF COLLEGE MATRICULATION

In attempting to find out what influence season of conception had on later mental development, each student's month of conception was calculated from the given date of birth, then all freshman data were sorted by month of conception. The normal total monthly conception rate for each state was calculated separately for the two sexes, using live-birth statistics for the earliest six years locally available (1917-18, and 1920-23). While these years do not cover all the birth years of the students used in our study, it is unlikely that this in any way invalidates the findings to be presented in the following paragraphs.

Each month's conceptions were calculated as percentage of those for the whole year, both for matriculating freshmen and for the whole state populations involved. The percentage distribution of freshman conceptions for each month of the year was then divided by the percentage distribution of total state conceptions for the same month and the result multiplied by 100. This gave the percentage deviation of freshman conceptions from the normal expectancy (100 per cent) for each month, based upon seasonal variations in total state conceptions. In all cases, percentage deviations of freshman conceptions from the normal seasonal distribution were calculated separately for the two sexes.

Table 1 and Fig. 1 set forth the final results of this calculation for over 45,000 freshmen matriculating in 4 state universities during recent years. With both sexes of all 4 states there is a marked preponderance of freshmen who were conceived in the late winter months. The number of freshman conceptions in the summer months falls consistently below the normal expectancy based on total conceptions throughout the state population concerned. It would seem that, in general, a child conceived in mid-summer heat is blest with only about 60 per cent of the likelihood of college matriculation that is enjoyed by one conceived in late winter. In view of the large numbers of students used in the study, these seasonal differences in college matriculation expectancy become highly significant, entirely beyond the realm of chance relationship.

TABLE 1

Season of conception and likelihood of college matriculation

MONTH OF CONCEPTION	AVERAGE NUMBER OF CONCEPTIONS* (6-yr. period)					TOTAL NUMBER MATRICULATING BY MONTH OF CONCEPTION					DEVIATIONS FROM NORMAL EXPECTANCY OF MATRICULATION (Normal = 100)				
	N. Car.	Kans.-Ky.		Wisconsin		N. Car.	Kans.-Ky.		Wisconsin		N. Car.	Kans.-Ky.		Wisconsin	
	female	male	female	male	female	girls	boys	girls	boys	girls	girls	boys	girls	boys	girls
January	3356	4374	4393	2443	2318	1062	717	607	1138	960	110	122	129	135	116
February	2948	3974	4267	2215	2125	970	660	466	899	802	114	123	110	118	105
March	2983	3958	4590	2306	2142	854	649	545	1163	1083	99	121	127	147	141
April	3228	4756	4137	2567	2424	939	564	406	685	757	101	89	82	77	87
May	3051	4531	4134	2499	2355	805	523	419	707	719	92	87	88	82	85
June	3340	4801	3991	2794	2626	861	589	450	1027	948	90	93	88	107	100
July	3401	4376	4209	2587	2474	874	529	438	951	855	89	92	95	107	97
August	3548	4487	4298	2668	2490	900	514	426	824	814	88	87	92	90	91
September	3232	4290	4213	2597	2424	889	607	421	873	809	96	107	94	98	93
October	3302	4523	4105	2661	2591	962	545	431	811	825	101	90	90	89	89
November	3501	4595	3703	2723	2590	1101	539	456	940	878	109	87	93	100	95
December	3566	4519	3766	2562	2391	1152	668	560	728	900	112	110	117	83	105
Totals						11369	7104	5625	10746	10350					

* Based on live birth statistics for each state (1917-18, 1920-23).

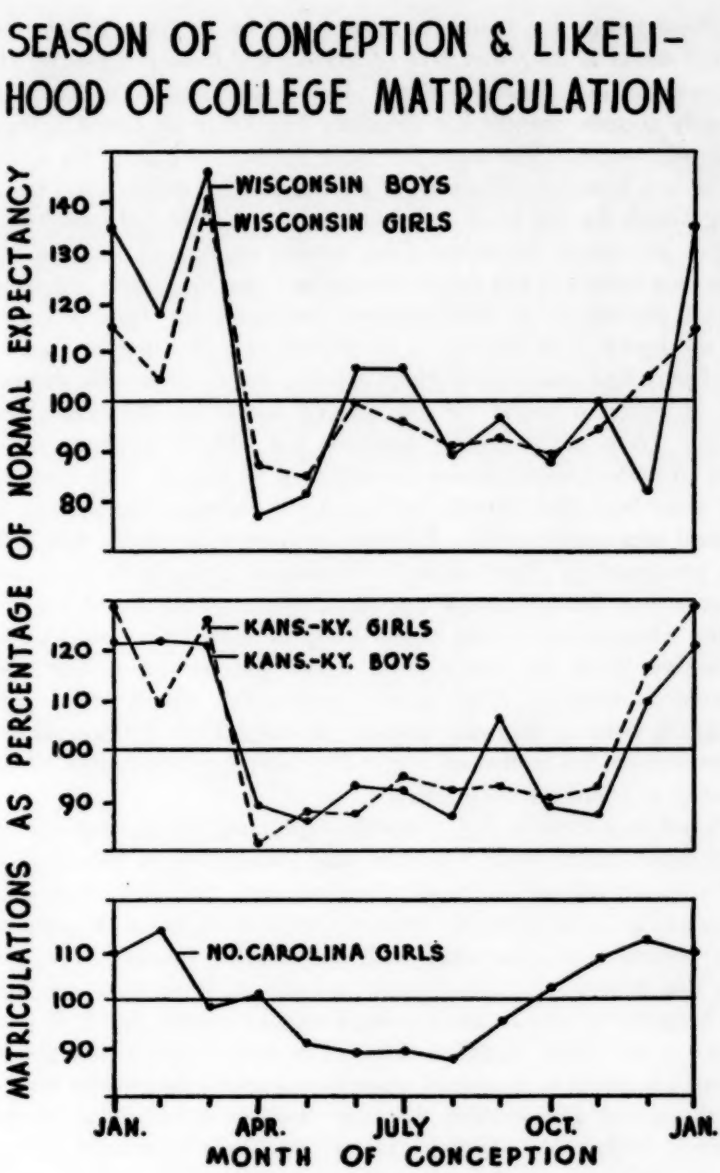
SEASON OF CONCEPTION & LIKELIHOOD OF COLLEGE MATRICULATION
MATRICULATIONS AS PERCENTAGE OF NORMAL EXPECTANCY
WISCONSIN BOYS
WISCONSIN GIRLS
140
130
120
110
100
90
80
KANS.-KY. GIRLS
KANS.-KY. BOYS
120
110
100
90
NO. CAROLINA GIRLS
110
100
90
JAN.
APR.
JULY
OCT.
JAN.
MONTH OF CONCEPTION

FIGURE 1

These results are similar to those found by Petersen for the list of starred names in *American Men of Science* and those reported by Huntington in his book *Season of Birth*. People conceived in the late summer or early autumn months are definitely less likely to attend college or attain distinction. The most favorable conception month for a life of distinction, however, differs slightly from that for college matriculation, being March for the latter and April for the former. Huntington fails to give percentage deviations from normal expectancy in most of his numerous materials, but rough calculation from his graphs indicates the highest percentage of distinguished people among April conceptions and the lowest with conception in September. Huntington found this true for 10,832 eminent Britishers listed in the *Encyclopedia Britannica*, just as Petersen found for the starred names in *American Men of Science*. It is not at present apparent just why the percentage expectancy of college matriculation should drop so sharply with conceptions that occur later than March, while that for distinguished persons holds up until later in the spring. Perhaps the answer lies in the fact that the data presented by Petersen and Huntington deal chiefly with people living in west central Europe and the northeastern section of the United States, where summer heat is less likely to come on so early or be so depressive as in the states from which the present college student material is drawn. Huntington's graphs for distinguished persons of Seville yields a seasonal curve of deviation from the normal expectancy very similar to that of Fig. 1 for college matriculations in North Carolina at about the same latitude.

It will be noticed in Fig. 1 that the expectancy of matriculation drops much more sharply with April and May conceptions in Wisconsin than at the lower latitude of North Carolina, and that this sharp drop is followed by a considerable rebound with early summer conception. This reduction in expectancy with early spring conception is greater than that brought by mid-summer warmth in Wisconsin. A hint of this behavior is seen in the Kansas-Kentucky curves, but it is entirely absent in the North Carolina data. The reason for this is not clear, although it might be explained upon Huntington's hypothesis that, during the spring reproductive tide, the stronger sexual urge results in relatively higher reproductivity among the lower classes of society in whom inhibitions function less strongly. It is during April and May that the conception rate rises most rapidly in such states as Kansas and Wisconsin. From December to March state conceptions decline sharply,

and a larger percentage of those conceived enter college. At other times of the year there is little relationship between changes in state conception rates and chances of college matriculation.

Among freshmen enrolling at the age of 16 years there is a very heavy predominance of January-March conceptions (births during October, November, and December), and in order to matriculate at 15 years of age an autumn birth is almost mandatory. This is not at all surprising, since boys and girls of these ages will be more likely to be ready for matriculation if they are almost ready to enter the next year's age group than if they shall have barely passed their 15th or 16th birthday. However, even the 19 year old age group of freshmen show the same preponderance of autumn births (January-March conception), and at this late matriculation age it would surely make little difference whether the individual had just passed his 19th birthday or was almost 20 years old. The data of Table 2 illustrate these statements

TABLE 2

Season of conception and likelihood of college matriculation
(15, 16, and 19 year old freshmen)

MONTH OF CONCEPTION	NO. OF 15 YR. OLD GIRLS MATRICULATING	DEVIATION FROM NORMAL EXPECTANCY IN NUMBER MATRICULATING (normal = 100)		MONTH OF BIRTH
		All 16 yr. old girls	All 19 yr. old girls and boys	
January	28	172	101	October
February	26	137	102	November
March	22	154	120	December
April	21	116	73	January
May	13	114	89	February
June	15	103	93	March
July	9	80	98	April
August	6	75	91	May
September	9	64	104	June
October	4	52	102	July
November	3	53	113	August
December	10	94	121	September

quite clearly. The rise of percentage expectancy of matriculation of 19 year olds with birth both before and after the actual month of college entrance (September) indicates that here age has little bearing on the tendency for those conceived in the colder half year to be more likely to enter college. Actual numbers of 15 and 16 year old freshmen were too small (less than 10 per cent) to have much effect upon the trends shown in Fig. 1 for the whole groups. We may therefore accept as a demonstrated fact the higher percentage of college matriculations among those conceived in winter cold than among those conceived in the summer months.

SEASON OF CONCEPTION AND MENARCHIAL AGE

Table 3 presents the data on mean menarchial age by month of conception. The retarding effect of summer conception is here seen to affect development during adolescence, for the menses begin significantly later in girls conceived in summer warmth than with those conceived in

TABLE 3

Menarchial age and season of conception

MONTH OF BIRTH	MENARCHIAL AGE				MONTH OF CONCEPTION
	North Carolina	Kansas	Wisconsin	All	
January	13.88	13.38	13.40	13.67	April
February	13.92	13.41	13.32	13.61	May
March	13.86	13.41	13.43	13.60	June
April	13.94	13.43	13.44	13.65	July
May	13.91	13.64	13.44	13.68	August
June	13.89	13.65	13.46	13.68	September
July	13.86	13.51	13.42	13.65	October
August	13.88	13.52	13.39	13.64	November
September	13.84	13.53	13.48	13.66	December
October	13.87	13.46	13.26	13.56	January
November	13.93	13.37	13.38	13.65	February
December	13.73	13.34	13.40	13.52	March
No. of cases	11,369	2,996	10,350	24,715	

winter cold. As seen from the North Carolina data given in Table 3, only in the case of February conceptions did the menarchial age rise above 13.88 years for those conceived during the colder seven months from October to April. With those conceived during the warmer five months, the menarchial age was above 13.88 years for all except the June conceptions. While the difference in mean age for the two conception periods in North Carolina is small (13.8602±0.0063 vs. 13.9031± 0.0124) the large number of cases makes it relatively stable. It is 3.1 times its own probable error, thus indicating that such a difference would occur by chance alone once in 26 times.

In calculating the seasonal difference in menarchial age for Wisconsin girls, the five conception months, June to October, were compared with the other seven. All five of these conception months show a mean menarchial age above 13.43, while in only one of the remaining seven does it rise above 13.40. The difference here is 3.2 times its own probable error, giving such an occurrence by chance alone only once in 31 times. The Kansas data of Table 3, although based on a smaller number of cases, shows the most marked retardation in onset of the menses with conception in the late summer heat (August and September). Taking the data for all three states, the mean menarchial age for July, August, and September conceptions is 13.6717±0.0112, and that for January, February, and March conceptions 13.47±0.0108. The difference (0.097±0.0155) is 6.26 times its own probable error, indicating that only once in many thousands of times would such a difference occur by chance alone. Taking only the 16 year old freshman girls, those conceived in January, February, and March show a mean menarchial age of 13.1786±8.0290 years, while for those conceived in the remaining months of the year the age is 13.37±0.0221. The difference between these two ages (0.1963+0.0365) is 5.4 times its own probable error and would occur by chance alone only once in several thousand times. It is to be noted that those girls matriculating at the age of 16 years had a significantly earlier onset of the menses than did those matriculating at later ages.

It seems evident, from these menarchial statistics, that season of conception does exert a lasting influence over the dynamics of later development. Girls conceived in winter cold come to the menarche at a significantly earlier age than do those conceived in summer heat. This occurs even though all be subjected to the same multiplicity of influences from the time of conception onward. While the difference between

TABLE 4. *Season of conception and height-weight values*

MONTH OF BIRTH	FRESHMAN HEIGHTS (*in inches*)									CONCEPTION
	North Carolina	Kentucky		Kansas		Wisconsin		All		
	girls	boys	girls	boys	girls	boys	girls	boys	girls	
January	63.99	68.91	63.50	69.38	64.14	65.94	64.24	69.37	63.82	April
February	64.04	69.05	64.04	69.31	64.05	69.73	64.15	69.48	64.15	May
March	64.01	69.15	63.66	69.02	63.80	69.65	64.22	69.42	64.02	June
April	64.01	68.68	63.67	68.94	64.17	69.71	63.99	69.38	64.02	July
May	64.01	69.13	63.87	69.08	64.45	69.66	64.09	69.43	63.96	August
June	64.10	69.42	63.62	69.10	64.27	69.76	64.18	69.56	64.12	September
July	64.06	69.28	63.68	69.14	63.92	69.58	64.23	69.41	64.00	October
August	63.93	68.65	63.66	68.85	64.16	69.57	64.11	69.25	63.97	November
September	63.95	68.62	63.62	68.88	64.20	69.65	64.04	69.23	63.99	December
October	63.98	68.92	63.57	68.98	63.95	69.54	64.04	69.30	63.95	January
November	64.01	68.99	63.94	69.15	63.94	69.57	64.11	69.47	64.02	February
December	63.94	68.99	63.71	68.75	64.08	69.61	64.21	69.30	64.02	March
	FRESHMAN WEIGHTS (*in pounds*)									
January	118.72	138.89	117.37	143.48	119.30	145.62	123.87	143.67	120.01	April
February	118.49	145.64	119.18	143.85	119.40	146.16	122.63	145.47	120.31	May
March	119.02	143.51	116.40	143.19	118.41	145.46	124.00	144.60	120.22	June
April	119.08	143.90	118.04	141.48	118.66	145.46	122.09	144.24	119.77	July
May	117.72	143.13	119.40	142.40	118.25	145.96	123.20	144.58	119.51	August
June	118.86	143.91	117.16	142.11	120.09	145.75	130.97	144.49	120.88	September
July	119.04	145.34	118.28	144.05	117.49	145.05	123.98	144.86	120.12	October
August	118.86	141.21	115.82	140.80	118.29	144.19	123.74	142.91	119.39	November
September	118.48	140.78	117.74	142.92	118.62	145.49	122.79	144.23	119.46	December
October	119.41	140.22	117.17	142.65	118.61	145.29	121.86	143.92	119.79	January
November	118.45	141.61	118.65	141.82	118.24	145.54	122.77	143.83	119.52	February
December	117.73	139.65	117.10	140.21	118.36	145.51	124.03	143.42	119.65	March

summer and winter conception is not so great here as with the likelihood of college matriculation, it none the less is of definitely significant proportions.

SEASON OF CONCEPTION AND HEIGHT-WEIGHT DIFFERENCES

In Table 4 are presented the height-weight data by month of birth and of conception. In both height and weight, freshmen conceived from November to March, inclusive, tend to be smaller than those conceived in the remaining months. Comparing July, August, and September conceptions with those of January, February, and March, we obtain the following:

Month of conception	*Boys*		*Girls*	
	Height (*inches*)	Weight (*pounds*)	Height (*inches*)	Weight (*pounds*)
July, Aug., Sept.....	69.4569±0.0270	144.4300±0.0211	64.0725±0.0200	120.0446±0.0155
Jan., Feb., Mar.....	69.3189±0.0249	143.7191±0.0187	63.9978±0.0187	119.6396±0.0218
Difference	0.1380±0.367	0.7109±0.0281	0.0747±0.0274	0.4050±0.0214
Difference/P_{diff}...	3.8	25.3	2.7	18.9
Occurrence by chance	1 in 95 times	practically never	1 in 14 times	practically never

The height differences become still more significant if we compare those conceived in the six months, May to October, with those conceived during the colder half year:

Month of conception	*Boys*		*Girls*	
	Height (*inches*)	Weight (*pounds*)	Height (*inches*)	Weight (*pounds*)
May to Oct.....	69.4522±0.0192	144.6832±0.0153	64.0407±0.0141	120.0618±0.0109
Nov. to Apr.....	69.2916±0.0185	143.6180±0.0136	63.9989±0.0119	119.6469±0.0105
Difference	0.1606±0.0267	1.0652±0.0207	0.0418±0.0185	0.4199±0.0151
Occurrence by chance alone	1 in 20000 times	practically never	1 in 7 times	practically never

The weight differences between summer and winter conceptions are over five times as great as are the height differences, for both male and female freshmen. Were the weight differences only twice those of height, then we might say that the students conceived in winter are

lighter in weight only because of a shorter stature. As it stands, however, there is significance to be attached to the differences in both height and weight. But just why those conceived in winter should be smaller in later life is difficult to say. Were the growth retarding influence of winter conception limited to girls alone, then we might reasonably link it to the earlier menarchial age shown by those conceived in winter. Long-bone growth in girls is cut short by an early menarche, since growth in height seldom persists after the onset of fertility (2-3 years after the menarche in the United States at the latitudes here concerned.) Boys show an even greater retarding influence of winter conception, however, without the same sharp limitation of growth time by adolescent sexual changes.

Summer conception, accompanied by a more generous supply of ultraviolet light and dietary vitamin D, might possibly give a greater impetus to skeletal growth than would be possible with winter conception, but that would not explain the even greater weight advantage of summer conception. For the present it seems necessary to leave unexplained these observed relationships between season of conception and later body size.

DISCUSSION

From the data here presented, it seems clear that season of conception plays an important part in an individual's later development. Winter conception (January, February, March) provides a significant advantage along lines of mental achievement. The higher metabolic level of parental protoplasmic vigor during winter cold seems to be transmitted through the germ plasm, and to exert a lasting effect upon the future course of the offspring. Earlier onset of the menses occurs, as well as a much greater likelihood of college matriculation. However, for some as yet unexplained reason, superior body size is favored by summer, rather than winter, conception.

We have here evidence of one of the earliest environmental influences at work shaping the individual's future course. The seasonal tide in parental vigor or protoplasmic activity seems definitely to be carried over into the new unit being conceived, and to become an integral part of the new individual's characteristics throughout life. Here we see the nearest approach to conjunction in hereditary and environmental influences.

The findings reported in these pages have a very direct bearing upon human eugenics. Present-day civilization is dominated much more largely by mental achievement than by physical, hence the importance of stressing eugenic factors that promote mental functions. It would seem highly desirable, therefore, that parents keep in mind the advantages offered their offspring by winter conception. Even the best hereditary background may be made much more effective if supported by proper season of conception.

SUMMARY

1. Likelihood of college matriculation rises high above the normal expectancy for those individuals conceived in the winter months (January, February, March) and is low with conceptions in summer warmth.

2. The menses in girls begin significantly earlier with conception in the winter months.

3. Height and weight of college freshmen, both males and females, are greater in those conceived during the warmer half-year (May to October inclusive) than with those conceived in winter cold (November to April inclusive).

4. These studies are based upon height, weight, and menarchial records of over 45,000 college freshmen.

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RACES OF THE WORLD — A DISCUSSION OF RECENT CLASSIFICATIONS

BY GRIFFITH TAYLOR

University of Toronto

DURING the last few years several comprehensive ethnological studies dealing with large portions of the world have appeared. It is noticeable that these publications do not support the view of those anthropologists who believe that racial classification is rather a waste of time; since, in their opinion, there is no such thing as a pure race. The problem is admittedly complex; but there are certain regions where fairly homogeneous racial groups occur, as well as transition areas where it is difficult to draw definite boundaries. The writer proposes to discuss in this short paper some of the deductions set forth in such recent books as *Rassenkunde und Rassengeschichte* (Stuttgart, 1934) by von Eickstedt, and *Races of Europe* (New York, 1939) by C. W. Coon; and to compare them with the results, based on an ecological approach, which appear in the writer's book *Environment, Race and Migration* (Chicago University, 1937).

In 1900 Ripley wrote : "Science has advanced since Linnaeus' type of *Homo Europeus alba* was made one of the four great races of mankind". It is disheartening to find that the two authors quoted above still continue to accept the 'European' or 'White Race' as one of the four main classes. I therefore propose to devote a few paragraphs to von Eickstedt's main classes; and then to describe how Coon's volume differs in this respect from earlier classifications.

Von Eickstedt's classification derives directly from the classic divisions originating from Linnaeus (1758), Blumenbach (1806) and Cuvier (1812). He divides human beings into four main divisions in his last enumeration, as follows: Europide, Mongolide, Amerikanide and Negride. Their distributions are shown in Fig. 1. These again are split into smaller groups, which he calls 'series', while each series in turn is subdivided into 'varieties'. There are about 60 of the latter, with which however I do not propose to deal. Apart from these major classes the writer finds most of von Eickstedt's book admirable.

Fig. 1 is traced from von Eickstedt's map, as regards the outline. It is unsatisfactory, since it is split along the Pacific; and so the Behring Corridor is not shown. Thus the map masks the real connection between the Amerind and Asiatic peoples. Only in the case of the large Negride Division is the major ethnic area at all satisfactory in the writer's

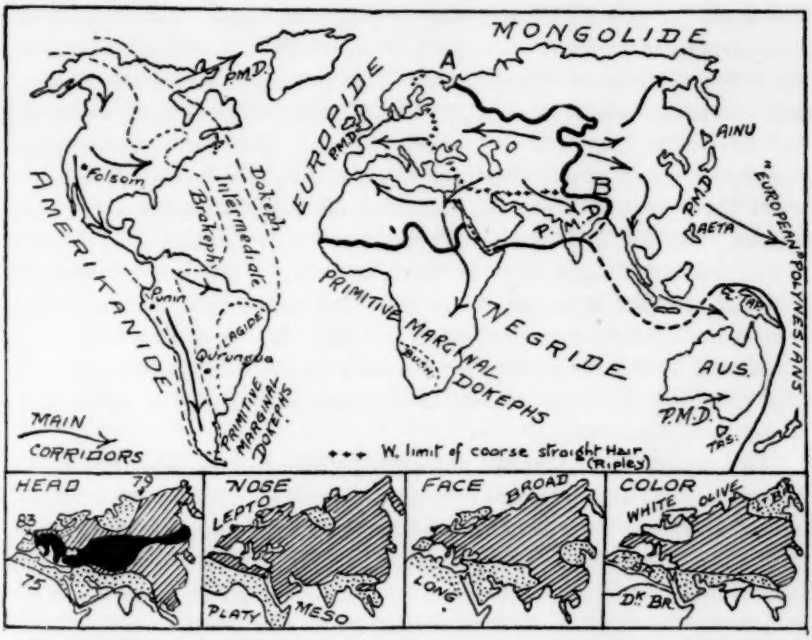

FIG. 1. A WORLD-MAP SHOWING THE DISTRIBUTION OF VON EICKSTEDT'S FOUR MAIN CLASSES: EUROPIDE, MONGOLIDE, AMERIKANIDE AND NEGRIDE

The remaining data shown support the alternative Migration-Zone concept of race. The four small maps demonstrate the inadvisability of separating Europeans and Mongolians as major races.

opinion. Many anthropologists now object to any wide separation of the Amerinds and adjacent Asiatics. Further, even though a similarity between the European types in the west and the Ainu and the Polynesians in the east is admitted in von Eickstedt's discussions, this is not indicated or explained in his main racial maps. Lastly, the heavy line (AB in Fig. 1), separating the European and Mongolian types, seems to the present writer to be contrary to all principles of racial evolution and ecology. I have given my objections to this grouping in my recent

book *Environment, Race and Migration* (pp. 202-206). But some of the more cogent are suggested in the four small maps at the base of Fig. 1.

All students of human migration must admit that there have been agelong westward and eastward migrations across Asia in the region of the Tarim Basin (see arrows in Fig. 1). This is true of the higher mammals, of primitive man, and of modern man. As a result the anthropological *isopleths* (i.e. lines of equal abundance) are *concentric* about this corridor in central Asia. This is shown in the four maps of Head index, Nasal index, Face breadth, and Skin color, which are derived from Biasutti's independent Atlas (Memoria Geographica, Florence, 1912). (Hair distribution is charted in the large map.)

If there were a real racial difference between European and Asiatic peoples, then the isopleths would run *parallel* to the line AB; whereas in the four small maps they run at right angles to this line. Hence AB does not separate biological areas in so far as the four very important criteria named are concerned. It is true that the 'epicanthic fold' of the eyelid, and 'shovel teeth' are found mainly in and around Mongolia; but why should such trivial criteria be adopted here and here alone as of major racial importance?

The writer has travelled through Japan, Korea, Manchuria, and Eastern China; and the small divergence which he has noticed as regards essential features between most of these folk and those living round the Caspian is noteworthy. Yet von Eickstedt and others isolate one group (the Mongolians) as a major race, while they accept the Caspian peoples as akin to the Alpines of central Europe. The present writer would extend the major Alpine Race far to the east of the line AB, so that it includes Mongolians, many late Polynesian folk, and most of the later Amerinds. The broken lines in the map of America (Fig. 1) are the writer's subdivisions of the Amerinds. They link directly with similar subdivisions in Eur-Asia.

The anthropologist who follows the century-old classes of Blumenbach and Cuvier does not realize that the continents are best considered as three *peninsulas* projecting from Central Asia. These three are Eur-Africa, southeast Asia with Australasia, and finally northeast Asia with the Americas. As I have demonstrated elsewhere the early human migrations moved into these three peninsulas mainly in order of their accessibility. Africa had the closest and broadest corridor from central Asia and therefore received most of the early Negro migrations. Aus-

tralasia came next, and received Negroes and Australoids in considerable numbers. The Behring Corridor was used by a few primitive tribes (probably of Australoid race), who were pursuing their usual prey thereabouts as far back as the last Interglacial. Among these we may find Folsom Man and Proto-Qurungua Man (*Environment, Race and Migration,* pp. 247, 251). But all the Amerinds undoubtedly entered in Recent times, probably within the last 20,000 years. The latter folk are mostly of Alpine or Mediterranean race.

Twenty years ago the writer discussed these ecological aspects of the problem, and gave it as his opinion that the major classes of mankind moved in the same fashion and in the same order *into all three* of the above 'peninsulas'. In each case somewhat primitive narrow-heads (dokephs) have been pushed to the margin (Fig. 1). Hence the classification of Blumenbach, etc. (which unfortunately is followed by many modern anthropologists) is highly unsatisfactory. It is not supported by modern isopleth maps of distribution, and is very unlikely in view of the environmental factors obtaining at the time of migration.

The ecological approach to the problem is clearly demonstrated in the stage-diagram given as Fig. 2. This shows (in black) the present-day distributions in the Old World for each of the five major races. The main criteria used are head index and hair type, which are surely as satisfactory as any criteria used by rival classifiers. In each case the race has moved out from south-central Asia. (Their abandoned earlier habitats are shown by dots.) No anthropologist has accepted my challenge (of 1919), and shown me why the races of man (prior to 10,000 B.C.) should not have obeyed Matthew's biological rules explaining dispersion in *zones.* All the difficulties with regard to the distributions of Amerinds, Polynesians, Negritoes, Ainu, Lolos, etc. are immediately solved if this classification (published in the *Geographic Review,* New York, December, 1919) is accepted. Details of the thesis have also appeared in HUMAN BIOLOGY in February, 1930 and September, 1936.

Let us now turn to the valuable treatise by Professor C. S. Coon *The Races of Europe.* It covers to some extent the same field as Ripley's *Races of Europe* (1900). But there is no similarity in treatment, and considerable difference in many of the conclusions. Ripley's book is very much easier to read, because it deals with races in the simpler fashion current in 1900. Coon's book contains many more anthropometric discussions and tables. A remarkable series of more than 500 photographs of the various types adds greatly to its value. It

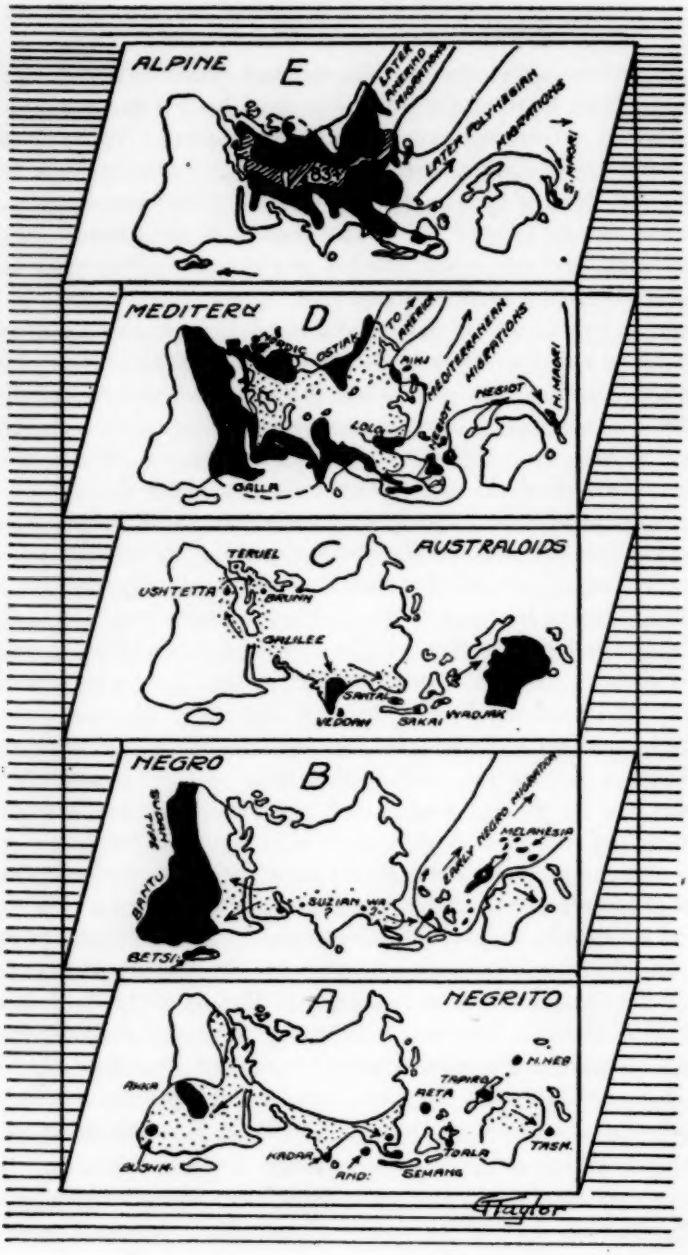

FIG. 2. A STAGE-DIAGRAM SHOWING THE FIVE STAGES OF RACIAL MIGRATIONS IN THE OLD WORLD, EACH REPRESENTING A MAJOR RACE

Black areas show present habitats. Dotted areas show probable early habitats. The lowest race in the diagram was the first differentiated, the highest was the latest.

might be described as an 'anthropological Baedecker' for every region in Europe, and as such is bound to be a valuable reference book for many years.

His main thesis is that the peoples of Europe are descended from two main racial groups. One of these includes the primitive 'Paleolithic Hunters' who lived in Europe in the last Ice Age. He calls these the *Neandertal-sapiens* hybrids. Coon believes that they are the chief components of the Alpine, Brunn, Borreby, Ladogan, and Lappish folk of Europe today. The second great division is descended from *Mediterranean* folk without any Neandertaloid blood; and they first brought agriculture and stock animals into Europe. From these 'Food-Producers' are derived the modern Mediterraneans, the Nordics, Dinarics, Armenoids, and the Irano-Afghan types of today.

Many controversial questions are raised by this book; but we have only space to discuss two or three. Coon seems to have adopted the "White Race" as a scientific entity, though his reasons are not clear to the present writer. Perhaps he felt that dealing chiefly with Europe this controversy was a matter of little import. In view of Ripley's strong and logical opposition to this concept of a White Race, this seems a serious omission. Secondly he does not seem to lay sufficient stress on the fact that numerous migrations (since Wurm Ice Age time) have poured into Europe along the Ukraine Corridor from central Asia. It is much more likely, in the present writer's opinion, that the broadheads (*brakephs*) of Europe today are descended from them rather than from the few brakeph Europeans of the Ice Age. Possibly the custom of cremation has destroyed much of the evidence of these later migrations. I should add that one admirable feature in Coon's book is the way that he has tried to interpret the *fossil* strata in the different districts.

Another important feature is his study of the hybrid types. Coon calls this "Dinaricisation", and discusses it in the light of his recent work on the Albanians. *Dinarics* result from a cross of two parts of Mediterranean with one part of Alpine. The stable type resulting has the narrow face and the long nose of the Mediterranean, while the head-breadth derives from the Alpine. The Dinaric type is also rather tall. *Armenoids* are similar hybrids of Alpine and Irano-Afghan. *Nordics* are "Iron-Age Nordics, brachycephalised by Dinaric mixture" (see Fig. 3).

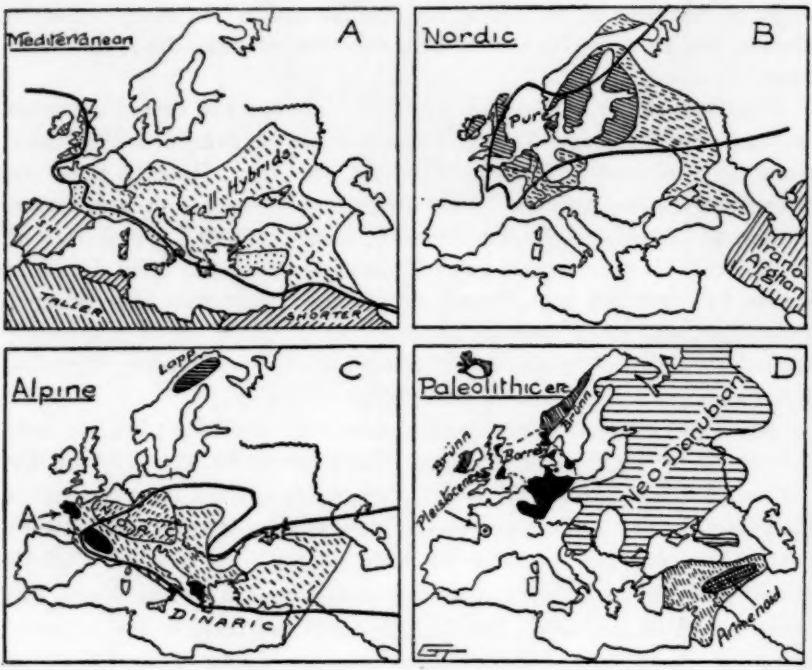

FIG. 3. RACES AND SUB-RACES IN EUROPE

The heavy lines show the generalized boundaries used in the writer's publications. In Fig. 3C the *black* patches show unmixed Alpines. In Fig. 3D the hybrid Neo-Danubians and Armenoids are also charted. (Mainly after C. S. Coon).

It is not easy to follow Coon's description of the *Neo-Danubians*, who occupy most of Russia. In my own published maps these were put down as strongly-Nordicised Alpines. Coon says that they are Ladogan (i.e. partly Mongoloid) crossed with the old *Danubians*. The latter is a Neolithic type of Mediterranean, with a higher vault and broader nose than usual. They do not seem to have had any contact with actual Alpines.

The last concept which I propose to discuss is one of the most interesting. This is the re-emergence of the Paleolithic types around the North Sea. We are all familiar with the ancient 'nests' found in the Dordogne and in Wales. But Coon extends their habitats greatly, and finds them in huge areas in North Germany and elsewhere. He traces

these primitive survivals in part by their *big* heads; and finds that they are most typically preserved in Fehmarn Island near Kiel. But he says that this *Borreby* Paleolithic survival "has become the most important single racial element in modern Germany" (p. 265). Since these folk are relatively brakeph, it is difficult to class them as any brand of Nordic.

In Fig. 3 these modifications of the simpler distributions (as employed by the present writer) are charted. They are based mainly on Coon's data, but unfortunately he does not give separate maps so as to isolate his types. Thus in Fig. 3 at A, the area to the southwest of the heavy black line shows the usually accepted realm of the Mediterranean race. Coon separates a taller type, which he calls Atlanto-Mediterranean. He also shows extensions of these two types (naturally in a less pure form) as suggested by the dots (shorter types) and dashes (taller types).

In Fig. 3 at B is shown my own boundary of the Nordics. In Coon's opinion few pure Nordics occur in Germany; and the largest numbers are to be found in Britain, Sweden and Lithuania. This finding should exercise the minds of those who support the 'Nordic Fetish'. He suggests that the *German* Nordics were killed off in the numerous wars of the Christian era. His Irano-Afghans are not far removed from Nordics; and an allied but less clearly defined Nordic type is present in central Russia (see dashes).

In Fig. 3 at C are charted the main Alpine affiliations. As before, the heavy line shows the limit used by the present writer. Only in the three regions of Brittany, Cevennes, and South Albania does Coon find pure Alpines, though he remarks that there are large areas in central Asia with Alpine groups such as the Tajiks. The distribution of the hybrid Dinaric and Nordic types is charted also. In the last map at D the interesting Borreby (and allied Brunn) 'Paleolithics' are charted. Here also are shown the areas occupied by the Neo-Danubians and Armenoids, though they have no connection with the Paleolithic survivals. One may conclude by saying that no serious student of European origins or cultures can afford to ignore Coon's stimulating treatise.

BLOOD GROUPS AND TYPES IN BAGHDAD AND VICINITY

BY WILLIAM C. BOYD* AND LYLE G. BOYD

Department of Biochemistry, Boston University School of Medicine

IN 1937 we were able to test a considerable number of Bedouin and city dwellers in and near Baghdad for blood groups and types. We also tested for taste reaction to phenyl-thio-carbamide, observed the presence or absence of mid-digital hair, and recorded roughly pigmentation of eyes, hair, and skin, in four arbitrary grades. The Bedouin results have already been published (Kayssi, Boyd, and Boyd, '38), and the results on the subjects from Baghdad and nearby villages are presented here.

In Baghdad there is a large colony of Jews, who according to their own traditions have been in Mesopotamia since Babylonian times, and who are in any case very different in appearance from European Jews. We were able to test a moderate sample of these, larger than any other yet reported. Younovitch ('33) has tested in Palestine a similar sample of Mesopotamian Jews, perhaps also partly from Baghdad, whom she characterizes as "Juifs babyloniens, parlant le dialecte mésopotamien de l'arabe. Ces juifs, exilés par les rois babyloniens, gardent depuis des centaines de générations la tradition de leur ancienne origine, bien qu'ils aient subi à certaines époques l'afflux de judaïsants."

There had been previous blood group tests in Baghdad for the classical A, B groups (Kennedy and MacFarlane, '36) and extensive studies of physical characters in 'Iraq, such as the work of Field ('35). So far as we know, our M, N and taste reaction results are the first for this area.

Our methods have been sufficiently described in previous publications (Boyd and Boyd, '37, '40). The new results are presented in Table 1.

* John Simon Guggenheim Memorial Fellow, 1935-6; renewal, 1937.

No extensive discussion of these results seems to be called for. Our results for the Baghdad Jews agree well with those of Younovitch for the Mesopotamian Jews in Palestine, but differ somewhat from the Jews tested by Kennedy and MacFarlane, who were mostly from Sandur and from Isfahan, Iran. The Asiatic Jews in general agree with the people among whom they live in having more group B and less group A than the European Jews. Our sample has somewhat less B than the Baghdad Moslems, but about the same as the Christians. In regard to the M, N types, the Baghdad Jews seem to have rather more N than their fellow townsmen, where the percentage is rather low, compared at any rate to that in Europe. It will be recalled that we found (Kayssi, Boyd, and Boyd, '38) the percentage of N in the Bedouin near Baghdad to be low, particularly in the south and east. Our A, B results for the Moslems agree well with those of Kennedy and MacFarlane, but our results for the Kurds differ somewhat, probably because of the smallness of our sample.

The Jews seem to show on the whole rather higher percentages of "tasters" for phenyl-thio-carbamide than the Baghdad Moslems, with possibly a little higher incidence of mid-digital hair. They seem to have somewhat darker eyes, somewhat more variable hair color, and rather lighter skins.

There is some indication that the Christians are a little less pigmented in general than the Moslems. Our sample of Kurds is too small to enable any statements to be made about it.

It will be observed that there is a general tendency for the males in our series to have darker hair and skin than the females.

Since not all of our subjects came from the city of Baghdad itself, and because we found significant variations in the M, N frequencies in various outlying regions of the vicinity, we have also tabulated our blood results according to localities. The samples from all the individual towns except Baghdad were so small that we have thought it more practicable to classify them according to their direction from Baghdad. See Table 2.

The figures for the city of Baghdad do not include the Jews. The variation in the A, B frequencies in the various localities is not very great, and it may be doubted if the subjects from the outlying regions show any particular difference in A, B frequency from the inhabitants of the town itself. On the other hand, the M, N frequencies, though also based on small samples, might suggest that in the northeast and

Table 1

Blood group and blood type frequencies, taste reactions to phenyl-thiocarbamide, and per cent of persons showing mid-digital hair and various degrees of pigmentation, arranged according to religion and nationality

Blood groups

RELIGION OR NATIONALITY	NO. (V)	PER CENT OF GROUP O	A	B	AB	GENE FREQUENCIES p	q	r	D/σ
Christians	63	30.2	39.7	19.0	11.1	.286	.151	.550	0.5
Muslims	386	33.7	31.4	28.2	6.7	.226	.208	.581	1.5
Jews.....	215	27.0	37.2	20.5	15.3	.281	.169	.520	2.14
Kurds	29	27.6	44.8	24.1	3.5	.326	.194	.525	1.2

The gene frequencies p, q, and r are calculated from the relations

$$p = \sqrt{\frac{A}{100} + \frac{O}{100}} - \sqrt{\frac{O}{100}}, \quad q = \sqrt{\frac{B}{100} + \frac{O}{100}} - \sqrt{\frac{O}{100}}, \quad r = \sqrt{\frac{O}{100}}.$$

$D = 1 - (p + q + r)$, $\sigma = \sqrt{pq/2V(1-p)(1-q)}$ (cf. Boyd, '38).

Blood types

RELIGION OR NATIONALITY	NO. (V)	PER CENT OF TYPE M	MN	N	GENE FREQUENCIES m	n	D/σ
Christians.....	63	38.1	47.6	14.3	.619	.381	0.6
Muslims.....	387	37.0	47.0	16.0	.605	.395	0.6
Jews.....	215	26.5	47.0	26.5	.500	.500	0.9
Kurds	29	58.6	27.6	13.8	.724	.276	1.5

The gene frequencies m and n are calculated from the relations

$$m = M/100 + MN/200, \quad n = N/100 + MN/200.$$

$$D = 1 - \left(\sqrt{\frac{M}{100}} + \sqrt{\frac{N}{100}}\right), \quad \sigma = \frac{0.5}{\sqrt{V}}$$

TABLE 1 (*Continued*)

Taste reaction to phenyl-thio-carbamide

RELIGION OR NATIONALITY	SEX	NO.	PER CENT POSITIVE	PER CENT NEGATIVE
Christians	Male	46	80.4	19.6
	Female	14	50.0	50.0
Muslims	Male	217	69.6	30.4
	Female	105	72.4	27.6
Jews	Male	55	80.0	20.0
	Female	113	84.1	15.9
Kurds	Male	19	68.4	31.6
	Female	4	100.0	0

Hair on second phalanx

RELIGION OR NATIONALITY	SEX	NO.	PER CENT WITH	PER CENT WITHOUT
Christians	Male	48	64.6	35.4
	Female	14	57.1	42.9
Muslims	Male	233	67.4	32.6
	Female	132	50.7	49.3
Jews	Male	69	71.0	29.0
	Female	136	59.6	40.4
Kurds	Male	21	71.4	28.6
	Female	8	75.0	25.0

Eye pigmentation

RELIGION OR NATIONALITY	SEX	NO.	PER CENT HAVING PIGMENTATION OF GRADE 1	2	3	4
Christians	Male	48	2.1	4.2	62.5	31.2
	Female	15	6.7	0	53.3	40.0
Muslims	Male	236	0.8	4.2	61.9	33.1
	Female	136	0	3.7	41.2	55.2
Jews	Male	60	5.0	5.0	31.7	58.3
	Female	132	2.3	3.0	21.2	73.5
Kurds	Male	21	0	4.8	80.9	14.3
	Female	8	0	0	50.0	50.0

TABLE 1 (*Continued*)

Blood group and blood type frequencies, taste reactions to phenyl-thiocarbamide, and per cent of persons showing mid-digital hair and various degrees of pigmentation, arranged according to religion and nationalty

Hair pigmentation

RELIGION OR NATIONALITY	SEX	NO.	PER CENT HAVING PIGMENTATION OF GRADE			
			1	2	3	4
Christians	Male	44	0	6.8	22.7	70.5
	Female	15	0	0	66.7	33.3
Muslims	Male	210	0	1.0	12.4	86.6
	Female	90	0	0	31.1	68.9
Jews	Male	57	0	3.5	28.1	68.4
	Female	119	0	2.5	23.5	74.0
Kurds	Male	20	0	0	5.0	95.0
	Female	8	0	0	75.0	25.0

Skin pigmentation

RELIGION OR NATIONALITY	SEX	NO.	PER CENT HAVING PIGMENTATION OF GRADE			
			1	2	3	4
Christians	Male	48	77.1	18.7	4.2	0
	Female	15	66.7	33.3	0	0
Muslims	Male	244	29.5	61.5	9.0	0
	Female	143	55.9	42.7	0.7	0.7
Jews	Male	70	65.7	34.3	0	0
	Female	144	73.6	26.4	0	0
Kurds	Male	21	38.1	57.1	4.8	0
	Female	8	62.5	37.5	0	0

southeast quadrants outside Baghdad, there is somewhat less N than in the town itself. This would be in line with our findings among the 'Iraq Bedouin (Kayssi, Boyd, and Boyd '38) where we found more striking differences, and were able to secure on the whole larger samples. The hypothesis might be made that many of the neighboring populations

TABLE 2

Blood groups in Baghdad region arranged by locality

	NO.	PER CENT OF GROUPS O	A	B	AB
Baghdad proper	203	32.0	32.0	29.6	6.4
Northeast	29	31.0	37.9	20.7	10.3
Northwest	73	31.5	30.1	30.1	8.2
Southeast	44	31.8	27.3	27.3	13.6
Southwest	32	43.7	31.2	18.7	6.3

Blood types

	NO.	PER CENT OF TYPES M	MN	N
Baghdad proper	200	33.5	50.0	16.5
Northeast	29	51.7	37.9	10.3
Northwest	73	35.6	48.0	16.4
Southeast	44	54.5	34.1	13.4
Southwest	32	31.2	46.9	21.9

to the east and southeast of Baghdad have N frequencies definitely lower than in the city of Baghdad, and lower than in the neighboring populations to the west and northwest. For a proper test of this suggestion we shall have to wait for more extensive determinations in this region.

SUMMARY

Results of determination of blood groups, blood types, and observations on taste reaction to phenyl-thio-carbamide, mid-digital hair, and pigmentation of eyes, hair, and skin, are presented for 63 Christians, 386 Moslems, 215 Jews, and 29 Kurds from Baghdad and vicinity. It is suggested that a difference in N frequency may exist between peoples to the east and peoples of Baghdad and to the west of Baghdad.

Thanks are due to the Director General of Health, Baghdad, for permission to carry out this work, and to numerous doctors at the Royal Hospital, the Jewish Polyclinic, the Children's Hospital, and the Jewish Hospital, for their kind assist-

ance. Special thanks are due to Dr. W. P. Kennedy, then at the Royal College of Medicine, who allowed us the use of his laboratory, and assisted us in other ways. We wish to thank also Dr. Henry Field, who encouraged us to undertake the work, and whose advice proved so often to be of help.

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NOTES

A NOTE ON SHELDON'S METHOD FOR ESTIMATING DYSPLASIA

SHELDON (1) has recently suggested a method for describing the body type of an individual in terms of a frame of reference consisting of three components that correspond roughly to Kretchmer's pyknic, athletic, and asthenic habitus. Each of these three components is rated on a scale of 7 steps and the rating for a given individual is determined on the basis of a height-weight index and 17 diameter measures over different parts of the body. The body is divided into five regions and a rating on each of the three components is made for each region. The regions are: (1) Head and neck (2) Thoracic trunk (3) Arms and hands (4) Abdominal trunk (5) Legs and arms. In addition to the average ratings over all the regions on the three components, Sheldon also provides a measure of interregion variation or dysplasia for each of the components. This measure is computed by taking the sum of the absolute differences between each of the ten possible pairs of the five component ratings.

Letting D represent dysplasia and P_1, P_2, P_3, P_4, and P_5, the five ratings for the component in question, then

$$D = |P_1 - P_2| + |P_1 - P_3| + |P_1 - P_4| + |P_1 - P_5| + |P_2 - P_3| + |P_2 - P_4| + |P_2 - P_5| + |P_3 - P_4| + |P_3 - P_5| + |P_4 - P_5| \quad (1)$$

However, should we arrange our measures in rank order such that $P'_1 \geqq P'_2 \geqq P'_3 \geqq P'_4 \geqq P'_5$ we would get the same result as in equation (1) but there would be no need for absolute brackets since all of the enclosed terms are positive. Upon removing the brackets and collecting terms we find that the expression reduces to

$$D = 4(P'_1 - P'_5) + 2(P'_2 - P'_4)^1 \quad (2)$$

[1] This equation affords a simpler method for computing the dysplasia measure than the one suggested by Sheldon.

Since the range $R = P'_1 - P'_5$

$$D = 4R + 2(P_2 - P_4) \tag{3}$$

If we take the average deviation about the median, P_3, we find that

$$AD' = (P_1 - P_3 + P_2 - P_3 + P_3 - P_4 + P_3 - P_5)/5 \tag{4}$$

$$\text{or } AD' = (P_1 - P_5 + P_2 - P_4)/5 \tag{4'}$$

$$= (R + P_2 - P_4)/5 \tag{5}$$

By combining equations (3) and (5) we obtain

$$D = 10AD' + 2R \tag{6}$$

It is clear from equation (6) that Sheldon's index of dysplasia is not a simple measure. Why a measure that is so complex should be preferred when simpler measures are readily available, is difficult to understand. Furthermore the invention of a new measure of variation entails another difficulty. If a probable error is not provided for the new measure, it is difficult to determine its reliability. For this reason it is more desirable to utilize established measures of deviation, especially if they are equally suitable.

One of the simplest methods for measuring variation is the standard deviation or its square, the variance. If two independent ratings are available for each region it is a very simple matter to determine the interregion variance and its reliability. Thus independent ratings could be made by two different observers on the same photograph or by the same observer on two different photographs of the same individual.[2] An example of the data is shown in Table 1.

The total variation that the individual in Table 1 shows over all of the ten ratings can be allocated to two major sources: interregion variation and intraregion variation. The residue variation, after the first two sources are accounted for, indicates the interaction that exists between these two sources of variation. On allocating the total variance in the pyknic component of this individual to its several sources, we obtain Table 2.

The analysis shows that the interregion variance is only .278 of the intraregion variance. There is no need to postulate an interregion

[2] It is not intended to indicate that these two different methods would yield identical results. The first would involve errors of judgment only, while the second would involve errors of photography. But the statistical treatment would be the same.

TABLE 1

Somatotype ratings for the pyknic component in one individual for the five body regions

REGION	FIRST RATING	SECOND RATING
I. Head and neck	1	2
II. Thoracic trunk	1	1
III. Arms and hands	1	2
IV. Abdominal trunk	2	2
V. Legs and feet	1	2

variance if it is no greater than the variance expected from the mere repetition of measures in the same region. Similar analyses could be made of the athletic component and of the asthenic component.

Where only one measure is available for each region the reliability of the dysplasia measure can not be determined. The interregion variance for several individuals, however, can be compared. By use

TABLE 2

An analysis of variance of pyknic measures for a single individual[1]

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	*F*
Interregion	1.0	4	.25	.278
Intraregion	0.9	1	.90	...
Interaction	0.6	4	.15	...
Totals	2.5	9	..	...

[1] After this manuscript arrived in galley proof Dr. John Fertig, Professor of Biostatistics at Columbia University called my attention to the fact that in Table 2 the intraregion variance would be better designated as between-rating variance. He further indicated that since the ratings are rather discrete and crude, it is too much to hope that the distribution of repeated ratings would satisfy the prerequisites of normality that the analysis of variance technique demands. The method indicated is therefore only suggestive of what could be done if more refined ratings were available. This holds true only for intra-rating variance. The interindividual inter component and interregion variances do not suffer from this difficulty.

of Fisher's (2) methods, it is possible to determine whether two estimates of variance differ significantly from each other. Thus we can compare individuals as well as groups to determine whether they differ significantly with respect to their interregion variance in a given body component. An example is shown in Table 3.

TABLE 3

A comparison of two individuals with respect to their interregion variances

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	$F_{.05}$
O_1.....	1.06	4	.265	4.08	6.39
O_2.....	.26	4	.065	...	...

When comparing the interregion variances of two individuals, one must obtain a ratio of 6.39 or more, if the individuals are to be considered significantly different in dysplasia. Evidently then, the individuals compared in Table 3 do not differ significantly in respect to the dysplasia shown in the pyknic component.

The occasion may also arise when an estimate of dysplasia over all of the components is wanted. This is easily obtained by classifying the measures by component, region, and rating as shown in Table 4.

TABLE 4

Distribution of 30 somatotype measures for one individual, by component, region, and rating

REGION	PYKNIC COMPONENT		ATHLETIC COMPONENT		ASTHENIC COMPONENT	
	1	2	1	2	1	2
Head and neck	1	2	6	5	2	3
Thoracic trunk	1	1	7	7	2	2
Arms and hands	1	2	7	7	2	3
Abdominal trunk	2	2	6	5	2	3
Legs and feet	1	2	6	5	3	4

The variation seen in this table can be allocated to four sources; intercomponent, interregion, intraregion, and interaction.

It is then possible to use the interregion variance over all components in the same manner as has been described for the dysplasia over a single component.

Where one measure only is available for a component in a given region, the total variance over the three components can be apportioned to three sources; intercomponent, interregion, and interaction. Such a distribution is given in Table 5.

TABLE 5

Distribution of variance over 3 components by region, component and interaction

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
Interregion	.02	4	.005
Intercomponent	5.42	2	2.71
Interaction	.09	8	.011
Totals	5.53	14	.395

In this case we cannot estimate the reliability of the interregion variance, but we are able to compare it with any other estimate of interregional variance over three components. Such a comparison is offered in Table 6.

TABLE 6

A comparison of two individuals with respect to interregion variances over all components

INDIVIDUAL	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	*F*
1	1.06	4	.26	52.00
2	.02	4	.005	....

Here we obtain an F ratio of 52.00. This indicates that the difference observed between the interregion variances or dysplasias, of the two individuals compared is significant since it could occur by chance less than one time in 100.

SUMMARY

Sheldon's method for estimating dysplasia has been analyzed and simplified. In view of its crude form, another method of estimating dysplasia has been suggested. By using the interregion variance as an index of dysplasia we are able to answer two important questions concerning such a measure. The first deals with its reliability which is determined by comparing it with the intraregion variance. The second question deals with the matter of individual differences in dysplasia. Since variances are directly comparable, the significance of their difference being a direct function of their ratio, individuals as well as groups can be compared in respect to their dysplasia measures.

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THE NEGATIVE ASSOCIATION BETWEEN INTELLIGENCE AND FERTILITY

IN HUMAN BIOLOGY, Vol. 12, p. 114, 1940, a paper was published by R. R. Willoughby and M. Coogan on "The Correlation between Intelligence and Fertility". In view of the startling conclusions arrived at by the authors it is desirable that some of the errors in this paper should be pointed out.

Willoughby and Coogan commence by criticizing the usual indirect method of deducing the association between intelligence and fertility, that is, by counting the number of sibs of persons of measured intelligence instead of counting the number of their children. It would be universally admitted that it is highly desirable that the direct measure-

ment should, if possible, be made, for it would supply useful information that cannot be obtained in other ways. Nevertheless, if this cannot be done, quite enough is known about measuring intelligence and about degrees of resemblance between relatives to satisfy most people that it is inconceivable that one association could exist without the other. Willoughby and Coogan choose to be hypercritical. This might be forgiven them if the material they produce as direct evidence were of any value and if the calculations were correctly performed. Unfortunately this is not the case.

In the first place the total numbers are very small—373 altogether. The effective size of the sample is, however, considerably less than this, for no fewer than 256 persons have no children at all, 199 of them because they are not married. Of the remainder 66 have one child, 37 have two, 9 have three, and 5 have four children. A sample of this size and peculiar composition could not reveal anything.

An equally important point is that the sample is highly selected, being composed of former high school pupils. It is well known that the negative association between fertility and certain other characteristics may be much smaller within the limits of such a selected group; it may even be positive on occasion. A good example of this occurs in Fisher's analysis of Wagner-Manslau's fertility tables (1935). In a study by Norman, Griffiths and myself (1938), we found a correlation of —0.22 between Otis Index of Brightness and number of sibs in an unselected group of 3,305 children. When, however, the group was divided into four sub-groups according to type of school, the correlations were —0.07, —0.07, —0.10, and —0.13. Only the last figure differed significantly from zero. Thus even had Willoughby and Coogan's sample been large no deduction could have been drawn respecting the association in the population as a whole.

Making a division at the median point for the sexes separately, the investigators found that the 71 cleverer men have had 32 children, the duller 71 have had 30; the cleverer 115 women have had 67 children, the duller 115 have had 58. Nevertheless, they state that the product-moment correlation is —0.12 and is significant. This leads them away from their original contention that the fault in previous studies has been the indirect measurement by number of sibs; they now become darkly suspicious even of the correlation between intelligence and sib number. As, however, it seemed inconceivable that this discrepancy could have any basis other than faulty arithmetic, I have recalculated the correlation

coefficient, using their Table 1. The coefficient is not —0.12 as they state; it is —0.02.

It is perhaps true that the product-moment correlation is not the best way of expressing the association between intelligence and fertility, for while intelligence test scores are normally distributed, sib-numbers (or offspring-numbers) are not. It is better to use the regression of intelligence on sib- or offspring-number. But it is absurd to suppose that the use of the correlation coefficient could lead to a totally wrong conclusion and, of course, the use of the unexceptionable regression coefficient leads to substantially the same result.

In view of the nature of the evidence presented I can only admire the audacity of the final paragraph (as far as it is clear to me) in which Willoughby and Coogan present their conclusions:

> "It is evident" they state "that the intelligence-fertility problem should be more extensively studied by direct methods. Pending such studies, we feel that the above evidence, particularly since it is concordant with such previous information as is available, warrants the following hypothesis: The traditional negative intelligence-fertility relationship does not exist, and, therefore, is without demographic or social significance; observed differentials are probably almost wholly of psychosocial, i.e. environmental origin, and may spring from such attitudes as overanxiety in the privileged and despair in the nonprivileged".

Such faith has a quality of wistful appeal reminiscent of arguments in favour of anti-vaccination, Fundamentalism, or a flat earth.

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